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REVIEW OF WORLD AVIATION

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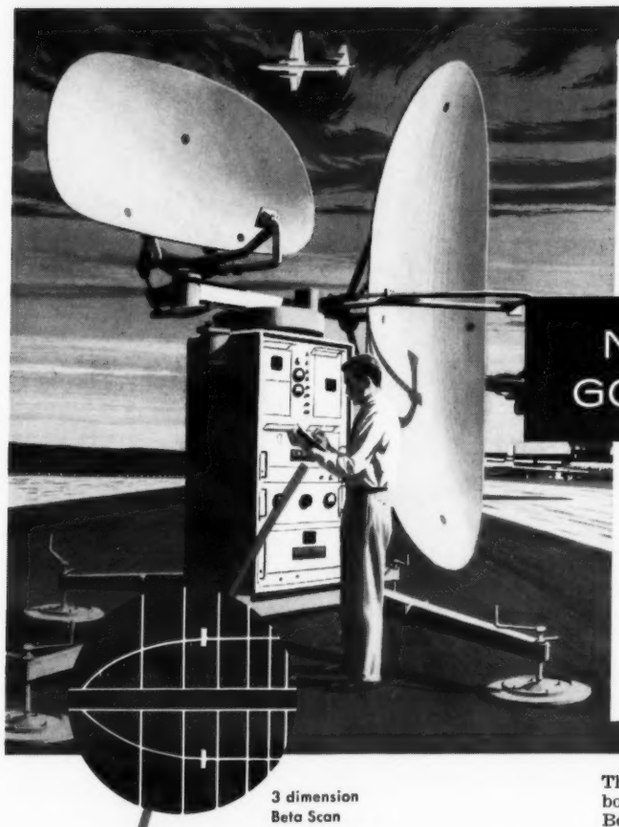
N.A.T.O. ISSUE Nº 2

If ... Atomic War Broke out Tomorrow?

VOLUME IX 8 1954



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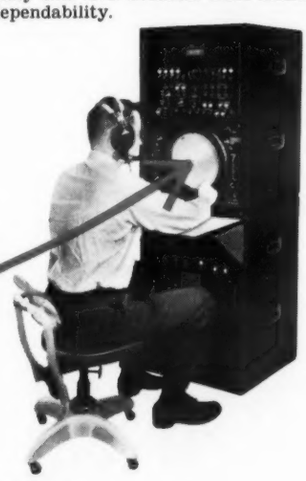

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Review of World Aviation

Volume IX — No. 8 — 1954

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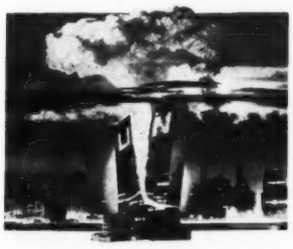

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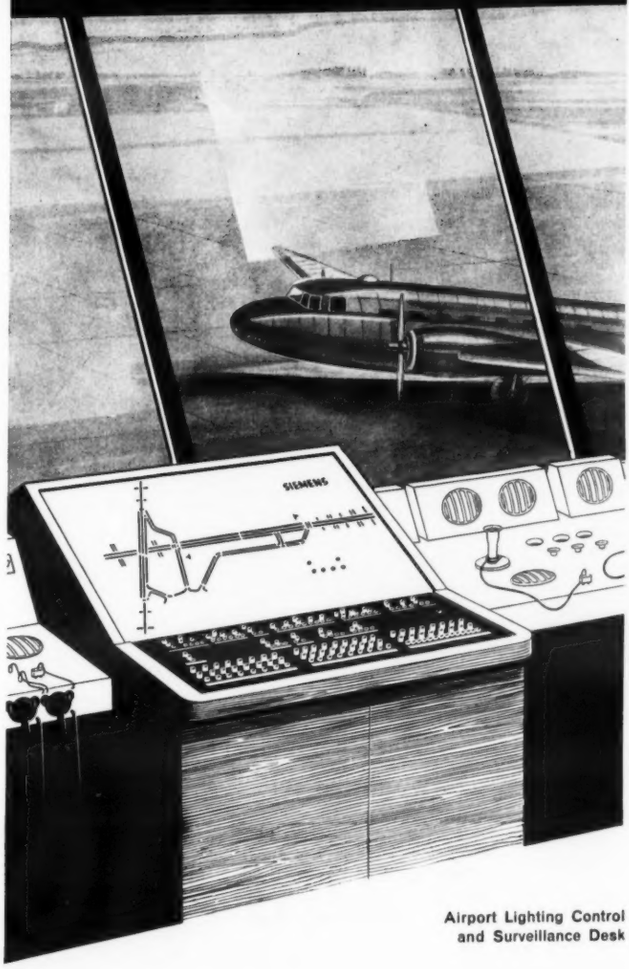

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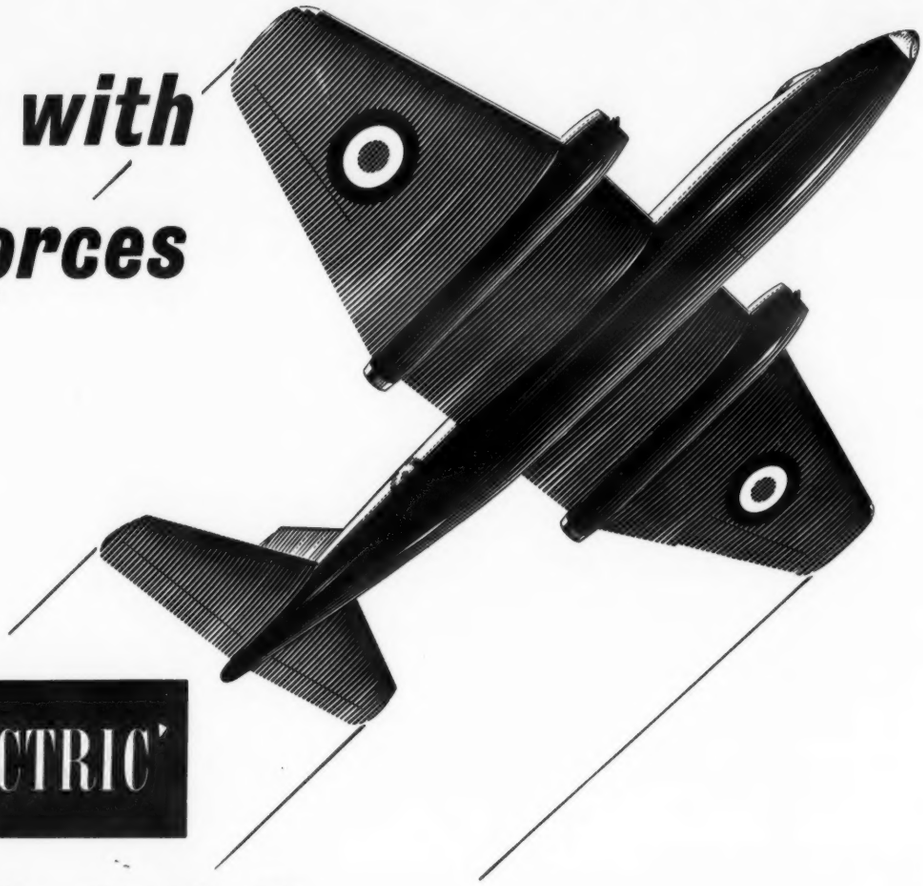

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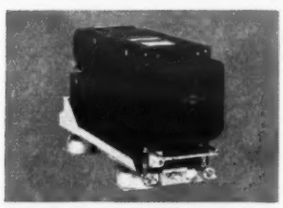

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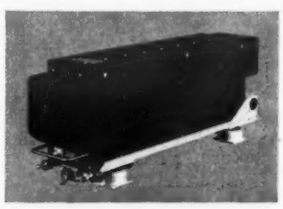

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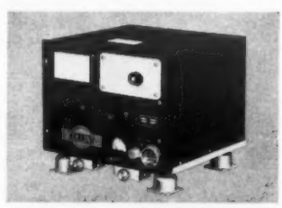

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UNITED AIRCRAFT EXPORT CORPORATION

J-57-POWERED NAVY F4D FIGHTER EXCEEDS SPEED OF SOUND

The first production model of the Douglas F4D "Skyray" jet fighter, with one Pratt & Whitney Aircraft J-57 turbojet engine and afterburner, exceeded the speed of sound in level flight June 5, 1954. Using the afterburner on take-off, the new U.S. Navy fighter was airborne in 1000 feet, and reached a speed of 450 miles per hour as it climbed past the edge of the airport at Los Angeles, California. Douglas' test pilot said the take-off was "something like being shot out of a cannon".

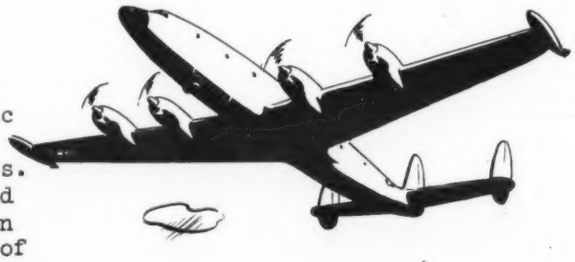
The production "Skyray" promises to be far more potent than the earlier F4D prototype, which in October last year, set a briefly-held world speed record of 753 m.p.h. The production airplanes' more powerful engine, the J-57, produces about 10,000-pound thrust, and considerably more with its afterburner in operation.

Designed as a carrier-based U.S. Navy interceptor, the F4D passed full carrier qualifications in September, 1953, and is now in quantity production at Douglas Aircraft Company's El Segundo division. The supersonic jet is expected to be in shipboard operation next year.

Two other fighter-type aircraft which use the Pratt & Whitney Aircraft J-57 turbojet and afterburner are also in production. They are North American's U.S. Air Force F-100, which holds the world speed record, and the U.S. Air Force F-102, built by Convair.

TURBO-HYDROMATIC PROPELLERS NOW IN PRODUCTION

Hamilton Standard is now producing huge, three-bladed Turbo-Hydromatic propellers for use on turboprop-powered military versions of Lockheed Aircraft Corporation's four-engined "Constellation" transport. The aircraft is being built for both the U.S. Air Force and the U.S. Navy.



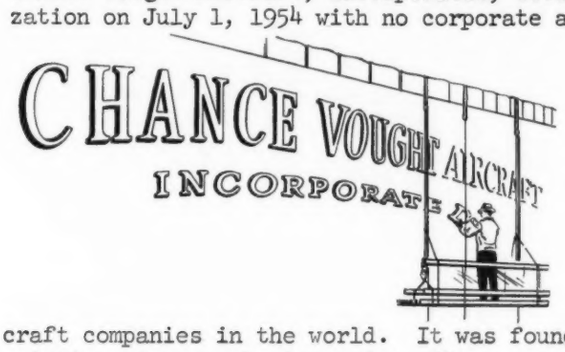
Designed as the A3470 model propeller, the new Hamilton Standard Turbo-Hydromatic was developed for use on propeller turbine engines in the 6,000-horsepower class. Behind it lie thousands of hours of ground and flight testing, much of which has been done with a turboprop engine in the nose of a converted B-17 "Flying Fortress" bomber.

The Turbo-Hydromatic is capable of extremely rapid pitch change, to match the sensitivity of the turbine engine. It features special controls for ground handling, its own oil supply, and many other advances in design which assure safety and reliability. It is the result of more than 12 years of continuous research and development in the turboprop field.

Commercial versions, and other models for higher speeds and engine powers are being developed in Hamilton Standard's extensive research facilities in Connecticut.

CHANCE VOUGHT AIRCRAFT NOW AN INDEPENDENT COMPANY

After many years as a manufacturing division of United Aircraft Corporation, Chance Vought Aircraft, Incorporated, became a completely separate business organization on July 1, 1954 with no corporate affiliations with United Aircraft Corporation.



The separation was decided upon last year. On January 1, Chance Vought was incorporated, and became a wholly-owned subsidiary pending completion of separation plans. The move will make it possible for Chance Vought to operate more freely and more effectively in America's competitive airframe industry.

Chance Vought is one of the oldest aircraft companies in the world. It was founded in 1917 by Chance Milton Vought, an aviation pioneer who learned to fly as a student of the Wright brothers.

Charles J. McCarthy has been elected Chairman of the Board of Directors of the new corporation, and has resigned as Vice President of United Aircraft Corporation to assume his new duties. Mr. McCarthy had been General Manager of Chance Vought during the early years of World War II. He is widely known for his long career in aviation, and for his work with the Institute of the Aeronautical Sciences, of which he was president in 1953. He will make his headquarters at Dallas, Texas, where the Chance Vought Cutlass fighter and Regulus guided missile are in production for the U.S. Navy.

SIKORSKY ROLLS OUT NEW ANTI-SUBMARINE HELICOPTER

Early in June, Sikorsky Aircraft rolled out its new XHSS-1 helicopter, a Navy aircraft designed especially for anti-submarine use. This new helicopter, like other Sikorsky types, has a single main rotor and tail rotor. The four main rotor blades and tail rotor assembly both fold for ease of handling and stowage aboard ship.

The XHSS-1 has one large 1420 h.p. aircooled engine mounted in the nose behind clam-shell doors. It has tricycle landing gear, and features a Sikorsky-developed automatic pilot, one of the first such instruments developed for helicopters.

The new helicopter is considerably larger than the familiar S-55 commercial type. It offers increased performance in range, speed, and load-carrying ability. A commercial version of the new Sikorsky, called the S-58, is not yet in production.

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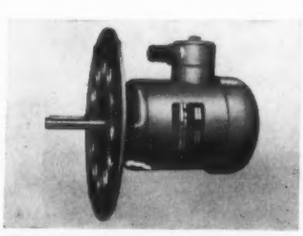

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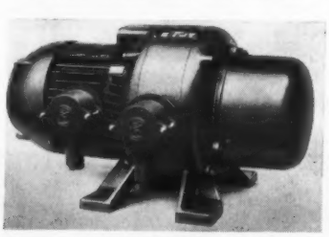

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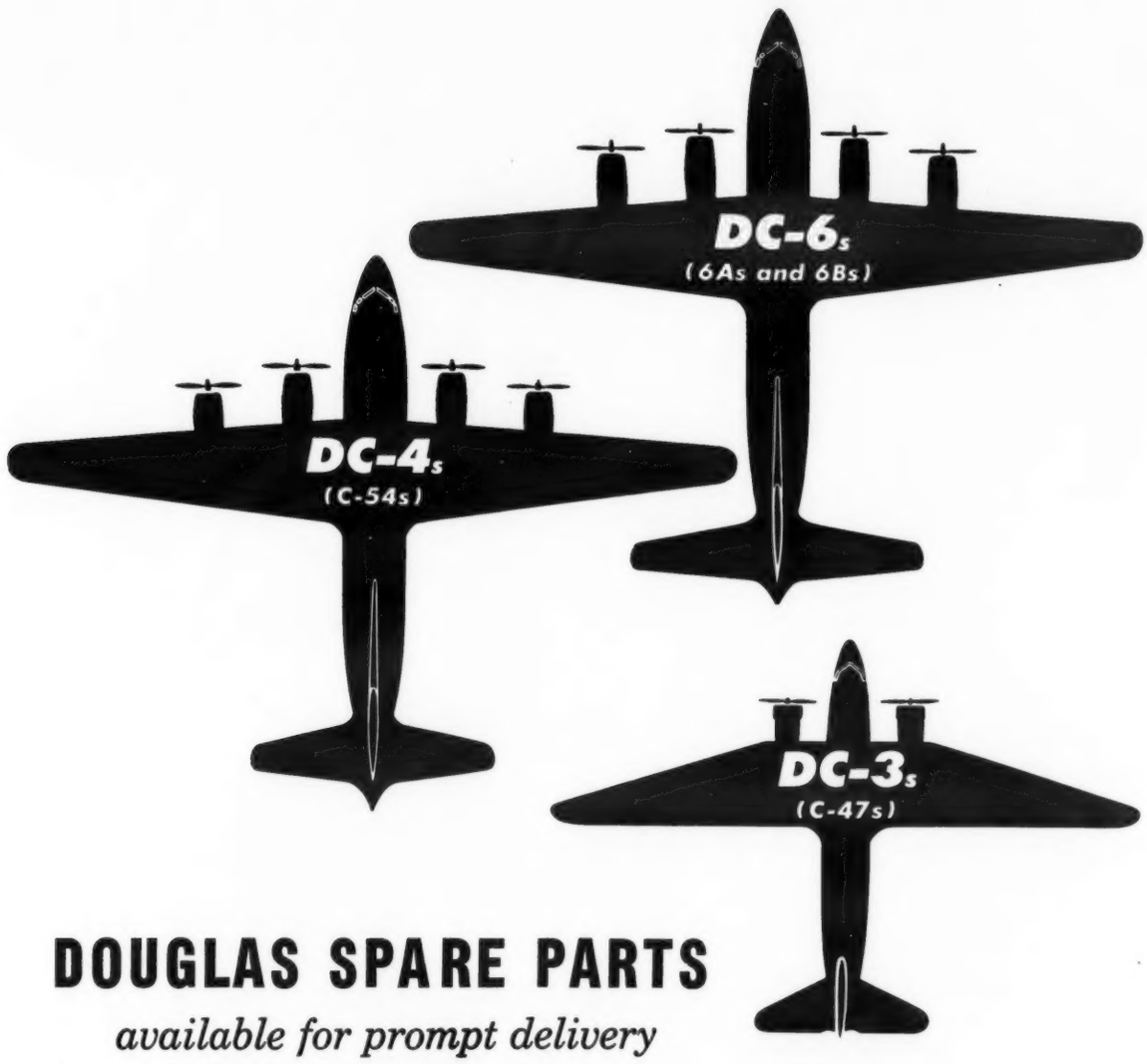

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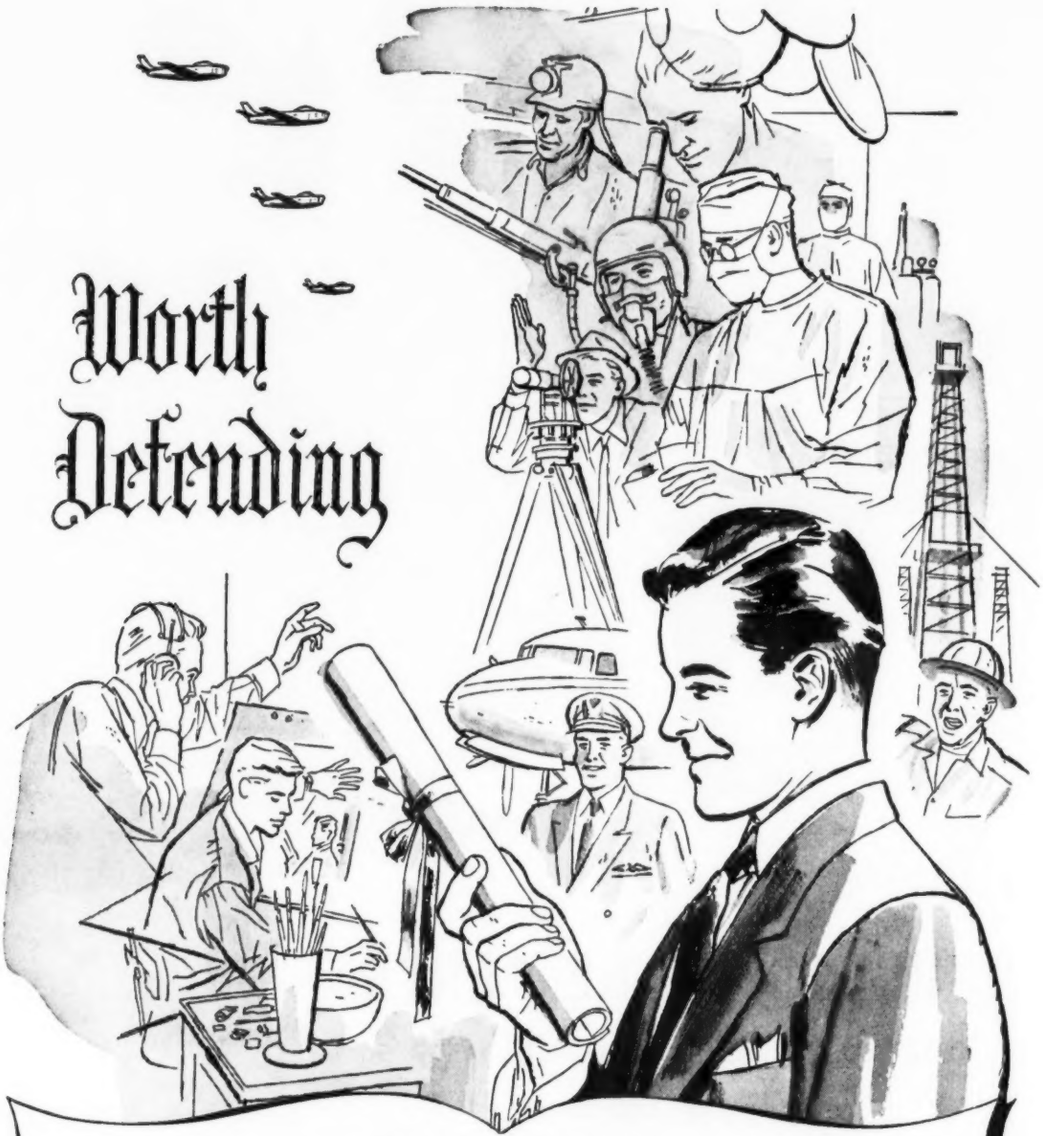

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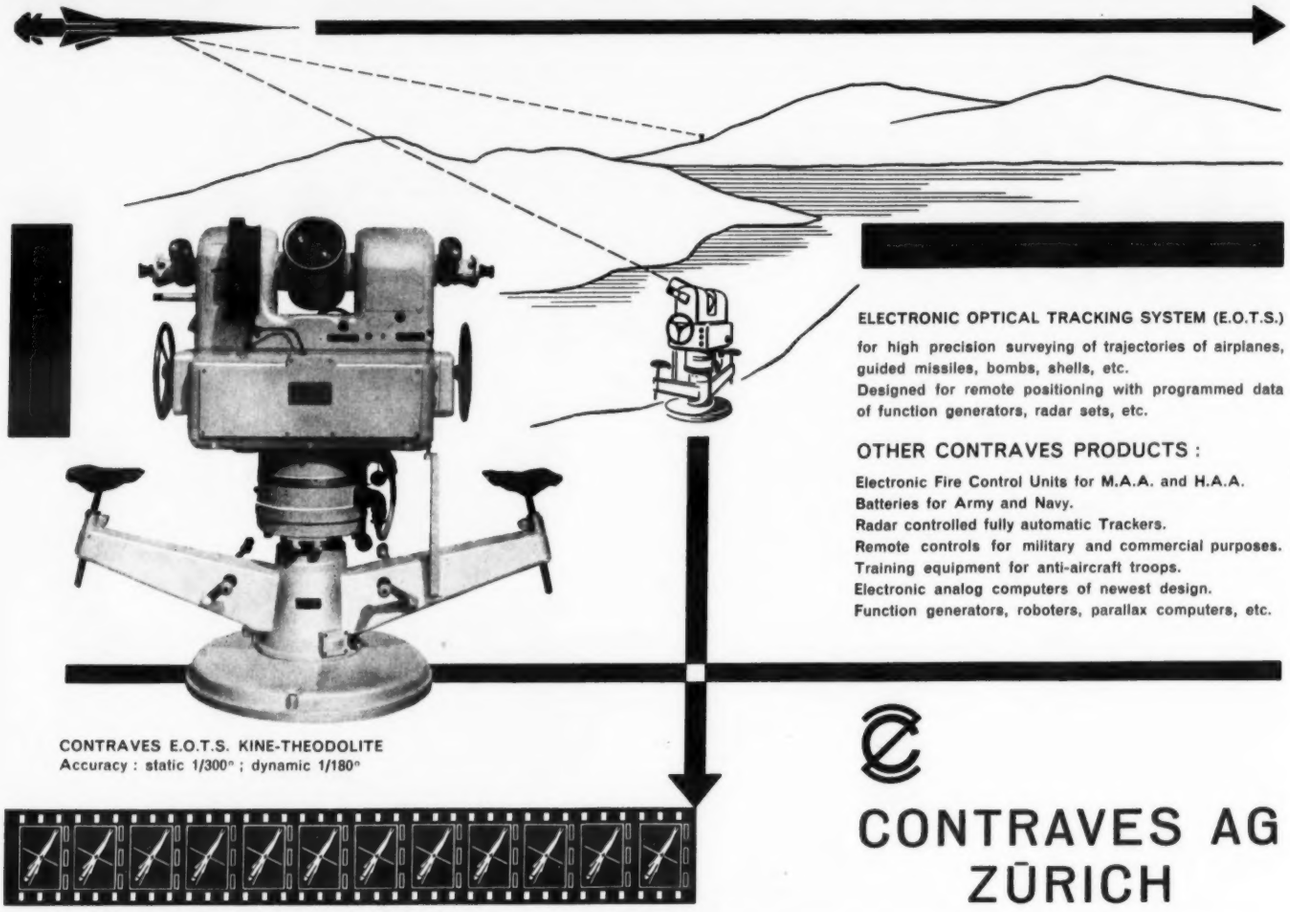

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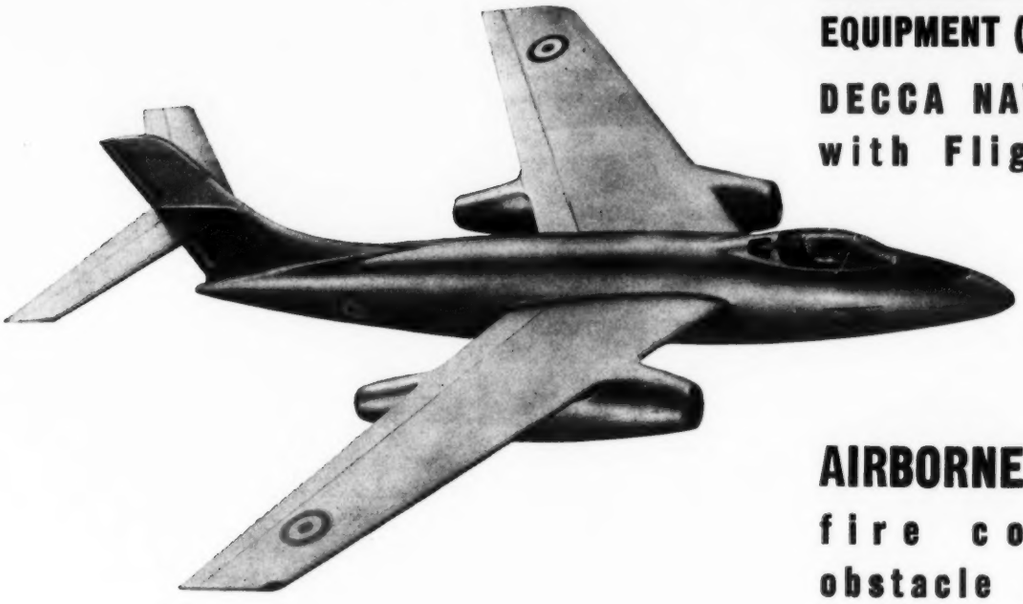

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obstacle warning

GROUND RADAR
surveillance and precision approach for airports
ground control of interception

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France : Mr. Guy Robert, Equipements d'Aérodromes, rue Tronchet 11, Paris 8, France.
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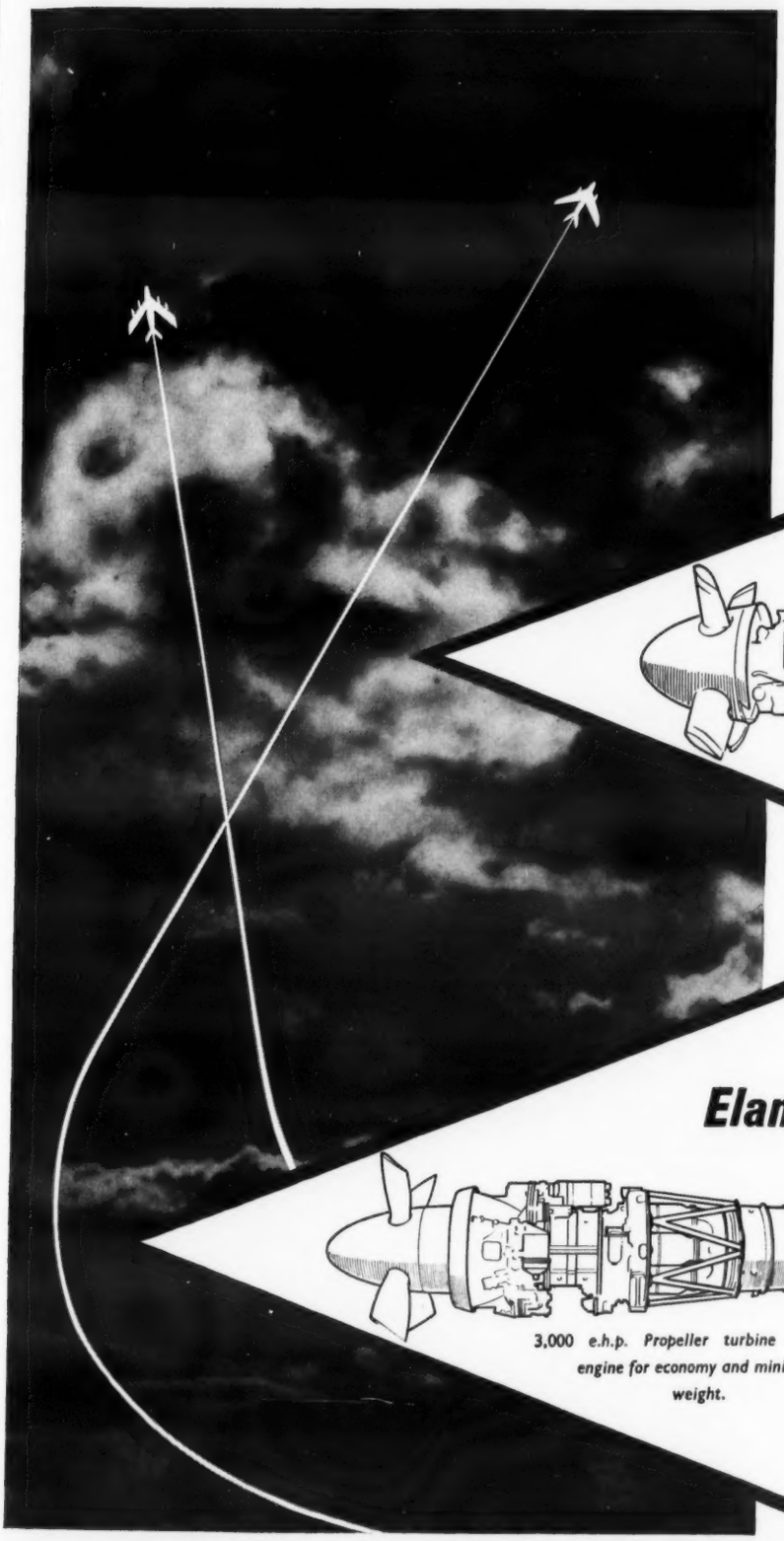
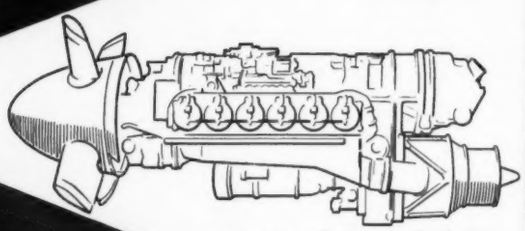
FARNBOROUGH 1954

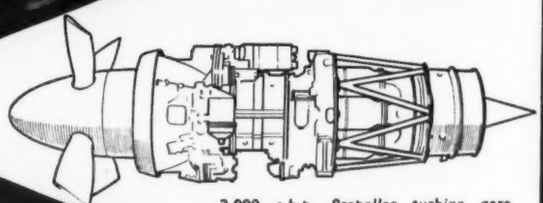


Nomad



3,135 e.h.p. Compound diesel aero engine for economy and longer range.

Eland



3,000 e.h.p. Propeller turbine aero engine for economy and minimum weight.

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the new Napier turbo-gas-generator for helicopter propulsion.

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— la digestion des corps étrangers soit impossible,
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— le cône d'échappement et les ondes de choc qui en sortent ne soient pas dirigés sur le fuselage au voisinage de la cabine passagers".

"CARAVELLE"

RÉPOND A CETTE TRIPLE PRÉOCCUPATION COMME A TOUTES CELLES DES UTILISATEURS.

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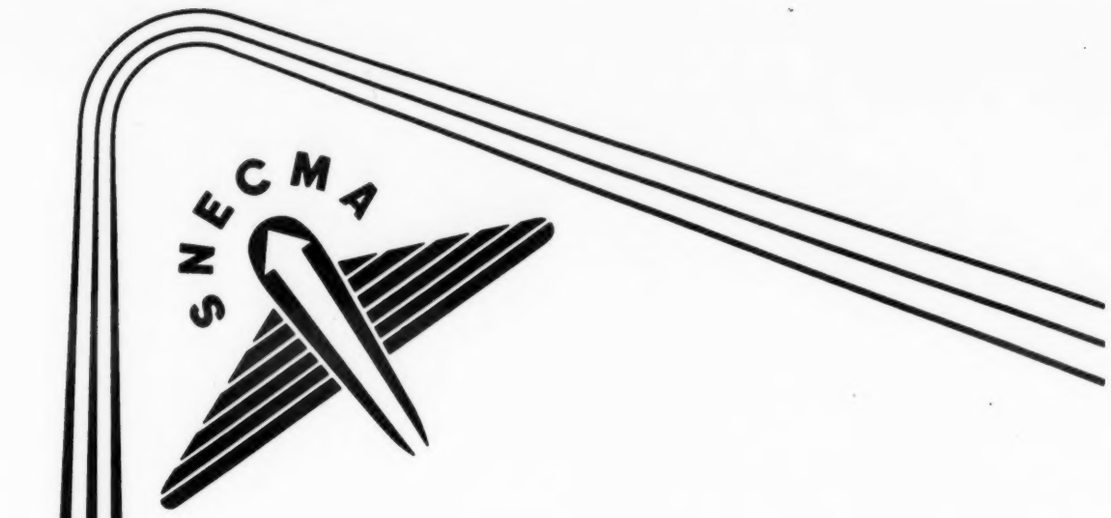


The "Atar" turbojet

April 5th, 1948
first test at ..... 3,750 lbs. thrust

July 4th, 1954
150-hour certification
on schedule, at ... 7,720 lbs. thrust

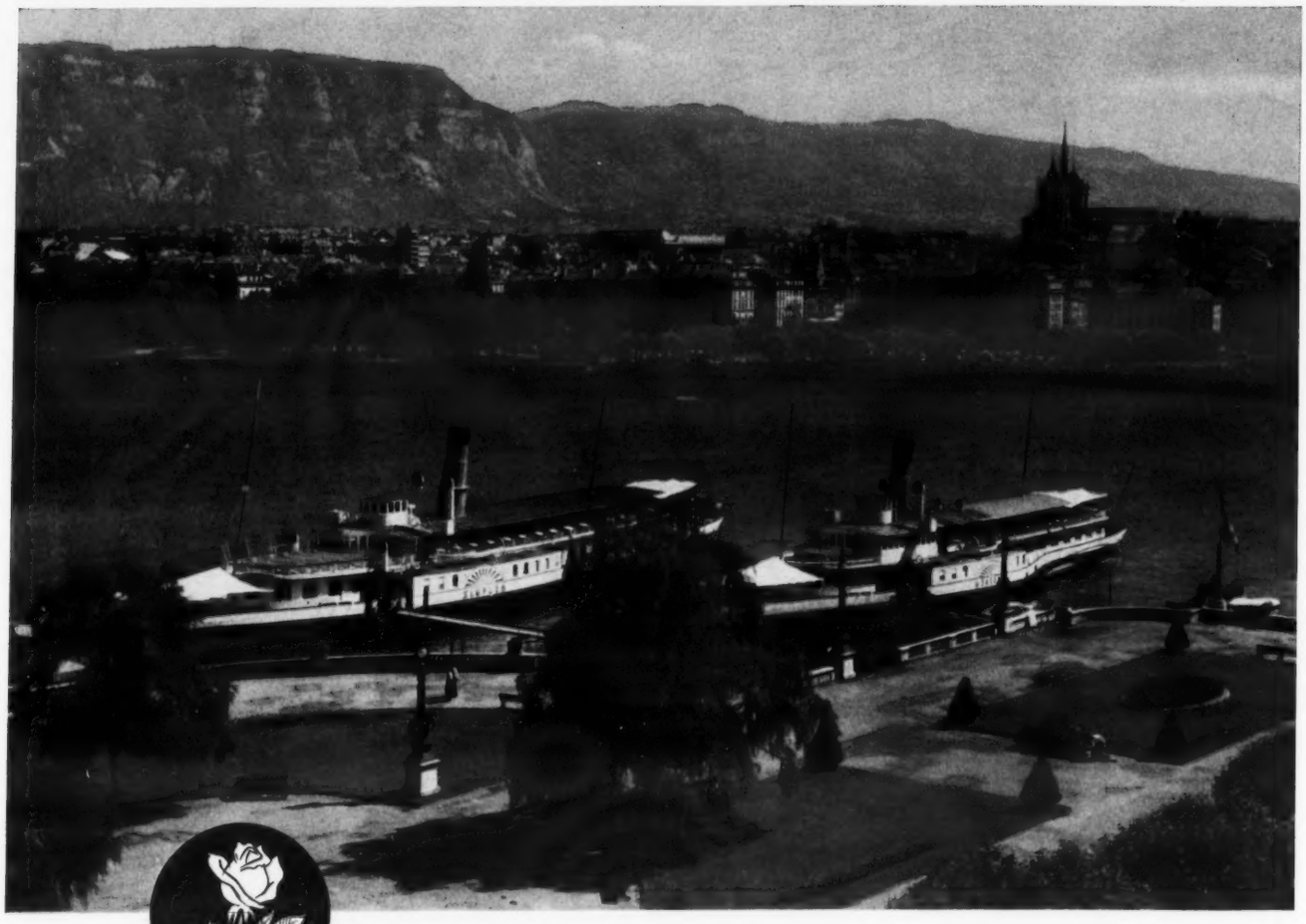
"Vulcain"

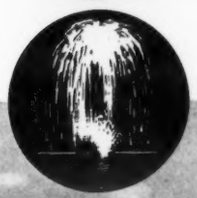
November 15th, 1952
first test at..... 10,000 lbs. thrust

May 20th, 1954
certification at .... 12,125 lbs. thrust

and...
the "jet deviator"

SOCIÉTÉ NATIONALE
D'ÉTUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION
150, Bd HAUSSMANN · PARIS 8e





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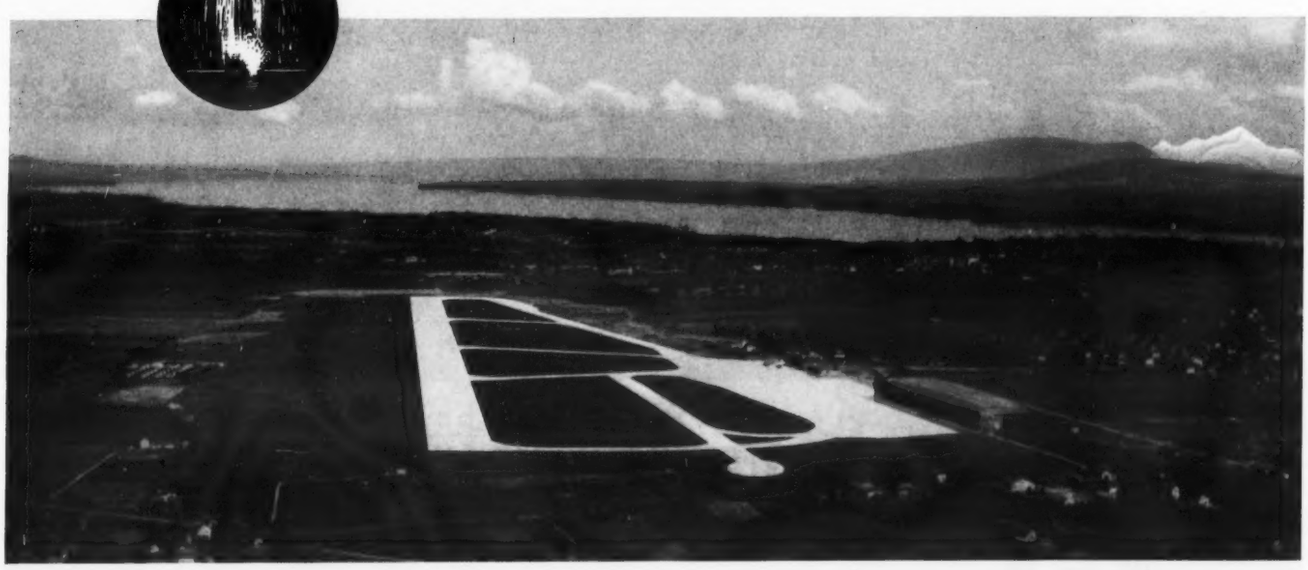
Gateway to the resorts of French-speaking Switzerland, the region of Lake Geneva and Mont Blanc.

European headquarters of the United Nations and of permanent international organizations.

Educational centre (summer University courses), conference city, home of industry and craftsmanship, crossroads of international trade and commerce.

Air services to all parts of the globe.

INTERCONTINENTAL AIRPORT



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PARIS ...

AMSTERDAM ...

DENMARK ...

MILAN ...

GENEVA ...

Western Europe

equips its aerodromes with

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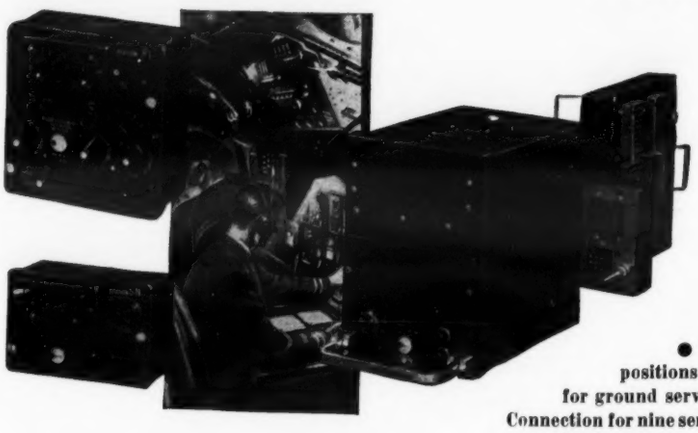
Aircraft Intercommunication



Marconi Equipment

Type AD 401 provides . . .

● ● ● intercommunication between up to ten positions in the aircraft and connection of mic/tel handsets for ground servicing crews.

Connection for nine services: four transmitter/receivers and five receivers or navigational aids.

Simultaneous mixing of four channels each having its own volume control: intercommunication plus three selected services.

MARCONI

Airport and Airborne Radio Systems

MARCONI'S WIRELESS TELEGRAPH CO. LTD.
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Features . . .

Self-contained power unit housed in amplifier unit.

Detachable chassis arrangement and robust construction for ease in servicing.

Lamp signalling between all station boxes.

Emergency override facilities.

The MINISTOP brake control

Weight of equipment:
2 lbs. per wheel

1952: Prototype built

1953: Tests in aircraft

1954: The "MINISTOP" is fitted in the production "MYSTÈRE IV"

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PEMA 5556

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ROLLS-ROYCE "DERWENT" 8 OR "NENE" 3 TURBINE

The highly specialized FOKKER S.14 "MACH-TRAINER" is an indispensable part of the planned fighter pilot training programs of the Western Air Forces.

The S.14 "Derwent" and "Nene" versions have been extensively tested by British, American, Netherlands, French, Italian and other foreign teams and the aircraft has demonstrated its excellent qualities as an advanced jet trainer.

Fokker

ROYAL NETHERLANDS AIRCRAFT FACTORIES

AMSTERDAM-SCHIPHOL-Z **TEL. ADDR.: FOKPLANES**

He needs only little light
... but this little is essential

The owl cannot fly at night
unless he can distinguish landmarks.
In complete darkness he is lost !
Similarly night flying would be impossible if the pilot had no illuminated runway to guide him during take-off and landing. Proper lighting is essential to the safety of flying. Backed by years of specialized experience, ADB Air Equipment's engineers design and build lighting systems of maximum reliability and maximum efficiency.

A D B

One of ADB's recent achievements: the equipment of a new instrument landing runway at Brussels National Airport.

Eight N. A. T. O. bases are fitted with ADB lighting equipment.

ADB Air Equipment S.A.

Surveys — Estimates
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Brussels — Belgium

High and low intensity runway lights, taxi-lights and approach lighting—Constant current regulators for series systems—Illuminated wind tees—Control desks—Obstruction and hazard lights—Airborne radio-electric runway-light remote controls.

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YOUR TRAVEL AGENT WILL ADVISE YOU

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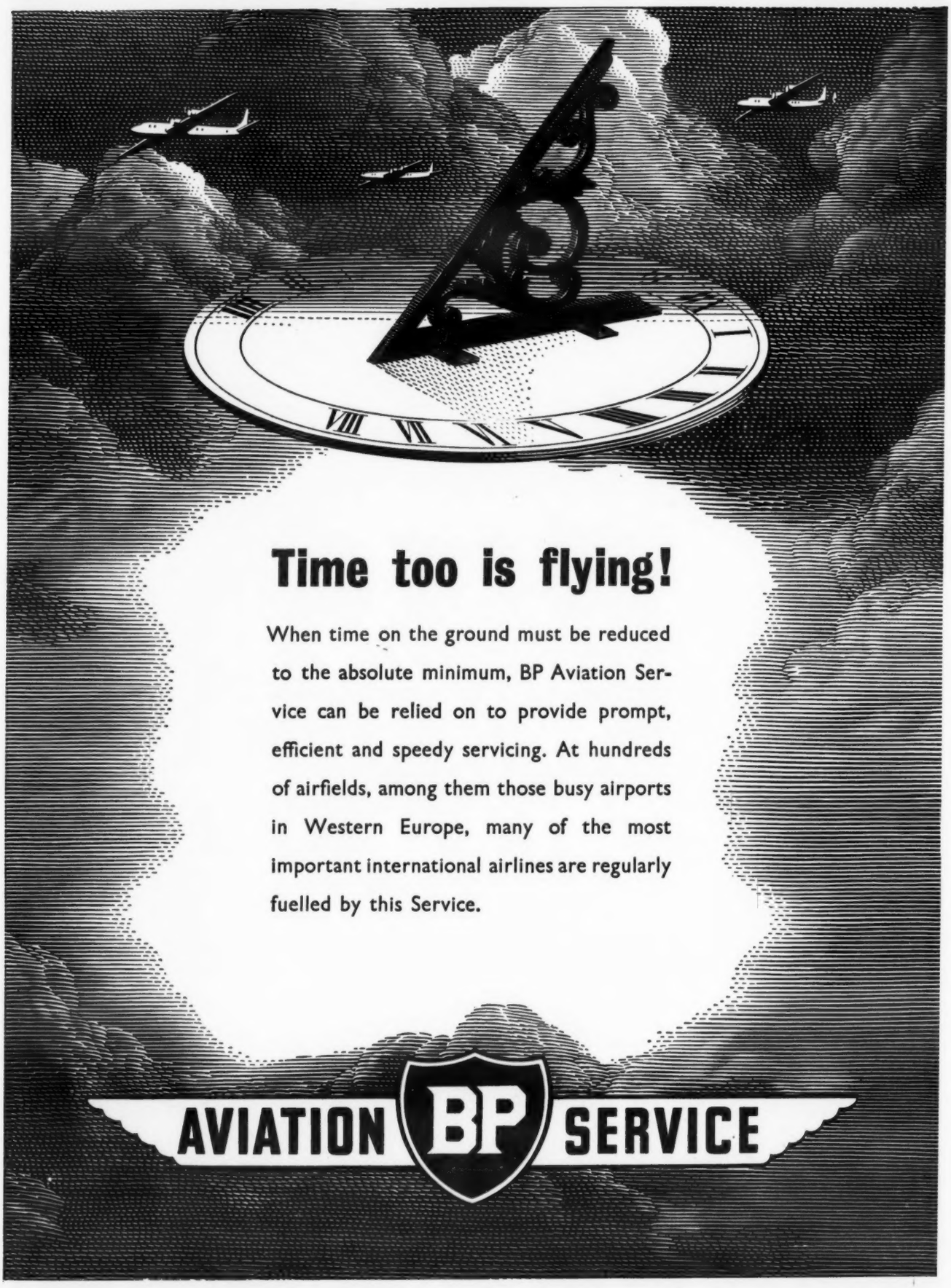
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When time on the ground must be reduced to the absolute minimum, BP Aviation Service can be relied on to provide prompt, efficient and speedy servicing. At hundreds of airfields, among them those busy airports in Western Europe, many of the most important international airlines are regularly fuelled by this Service.
AVIATION BP SERVICE

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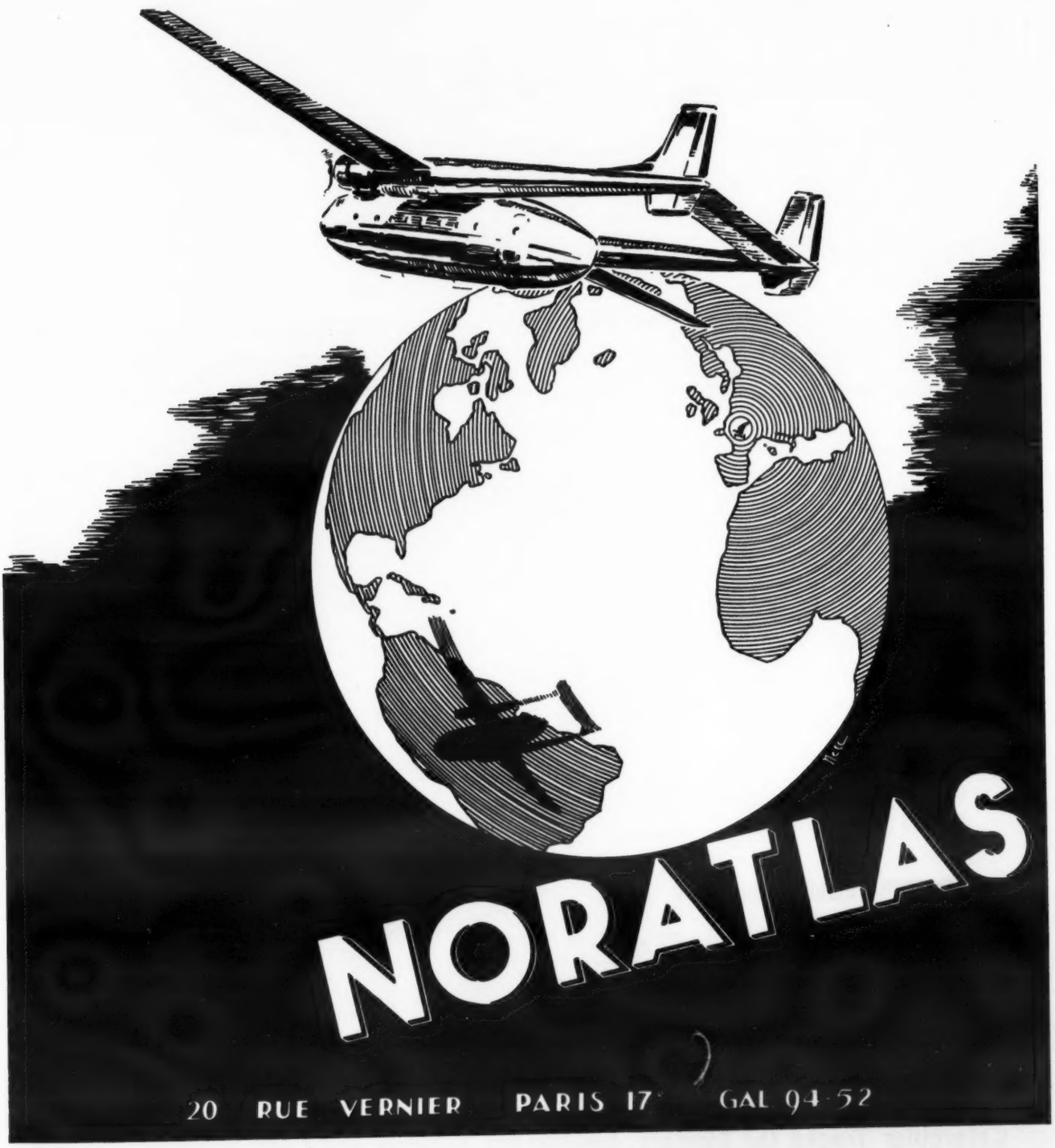

NORATLAS

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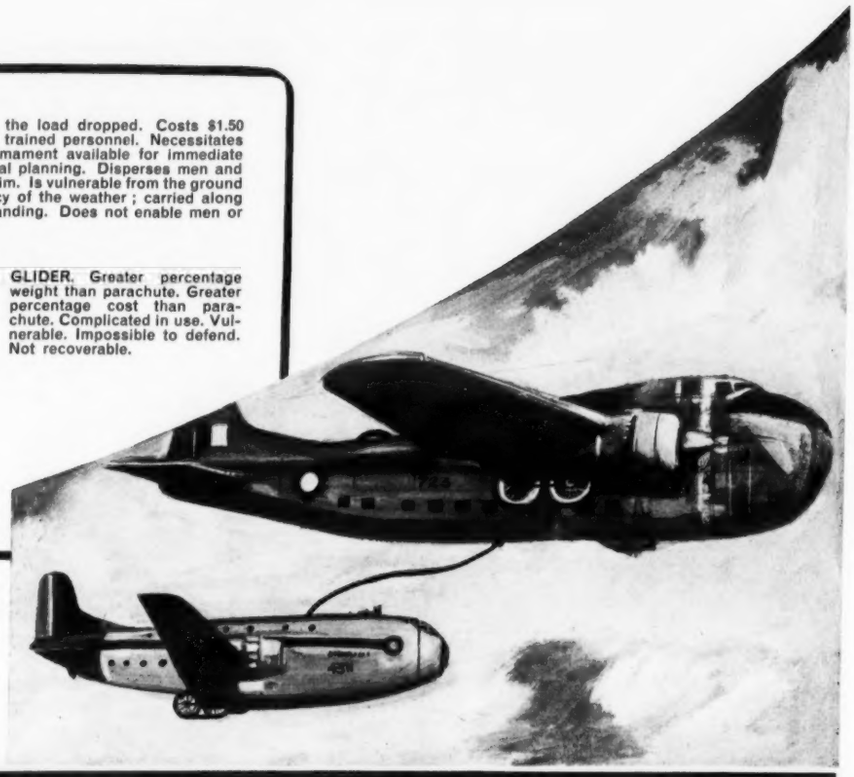
TODAY

PARACHUTE. Weighs 8 to 10 % of the load dropped. Costs $1.50 per pound dropped. Requires highly trained personnel. Necessitates a departure air base. Limits the armament available for immediate use by the parachutist. Limits tactical planning. Disperses men and equipment because of inaccuracy of aim. Is vulnerable from the ground during slow descent. Is at the mercy of the weather ; carried along by wind. Does not guarantee safe landing. Does not enable men or equipment to be recovered.

GLIDER. Greater percentage weight than parachute. Greater percentage cost than parachute. Complicated in use. Vulnerable. Impossible to defend. Not recoverable.

HELICOPTER. Costly to purchase, to operate and to maintain. Slow. Vulnerable. Impossible to defend. Not suitable for altitude. More sensitive to weather than the aeroplane.



TOMORROW

AIRCRAFT WITH CATERPILLAR TRACK UNDERCARRIAGES OPEN UP NEW LOGISTIC, TACTICAL, STRATEGIC AND ECONOMIC HORIZONS

Same weight as tandem undercarriage.

Same cost as tandem undercarriage.

Take off as with tandem undercarriage.

Retractable in normal way.

Need no prepared airfields.

Eliminate need for transit stores.

Eliminate need for transhipment.

Transport direct, with in-flight refuelling, from production centre to point of employment.

Accelerate supplies and provide them in time.

Reduce the need for shipping and ground transport.

Enable war production to be cut down.

Enable men and equipment to be recovered.

EST Etablissement Sciences Techniques

VADUZ (Liechtenstein)
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Caterpillar Tracks for Aircraft, Amphibious Vehicles and Land Vehicles

BONMARTINI Patents

SAFIR 91B

offers outstanding training economy

This side-by-side all-metal aircraft has found widespread use as a primary-basic trainer. The high training value of the 91B permits direct transition to advanced jet trainers. This three-seat aircraft can also be equipped to carry two machine guns and light bombs or rockets.

Adopted by seven governments

SAFIR 91C

- new four-seater -
the world's most versatile light aircraft

This new version of the famous Saab 91 Safir has comfortable accommodation for four people plus luggage but can also be used as an ambulance plane carrying one stretcher case and a medical attendant. By removing the rear seats it can take a quarter-ton of freight. The 91C is also an excellent trainer.

SAAB

SVENSKA AEROPLAN AKTIEBOLAGET
(SAAB AIRCRAFT COMPANY) • LINKÖPING • SWEDEN

Le Vautour

The speed of a fighter
The power of a bomber

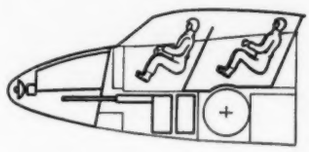
The VAUTOUR is being mass-produced in its three versions for the French Air Force

Comfortably exceeding the speed of sound, it is one of the fastest planes in the world in its category • The ease with which it can be converted permits economical standardization of manufacture and use • It can readily be equipped with any of the most powerful jet engines, such as the ATAR, AVON, SAPPHIRE • Owing to its large capacity and useful load, the VAUTOUR has a long flight endurance (several hours) and can carry a very powerful armament • It can operate from short or makeshift strips.

The VAUTOUR is the combat aircraft best suited to European needs

SNCASO

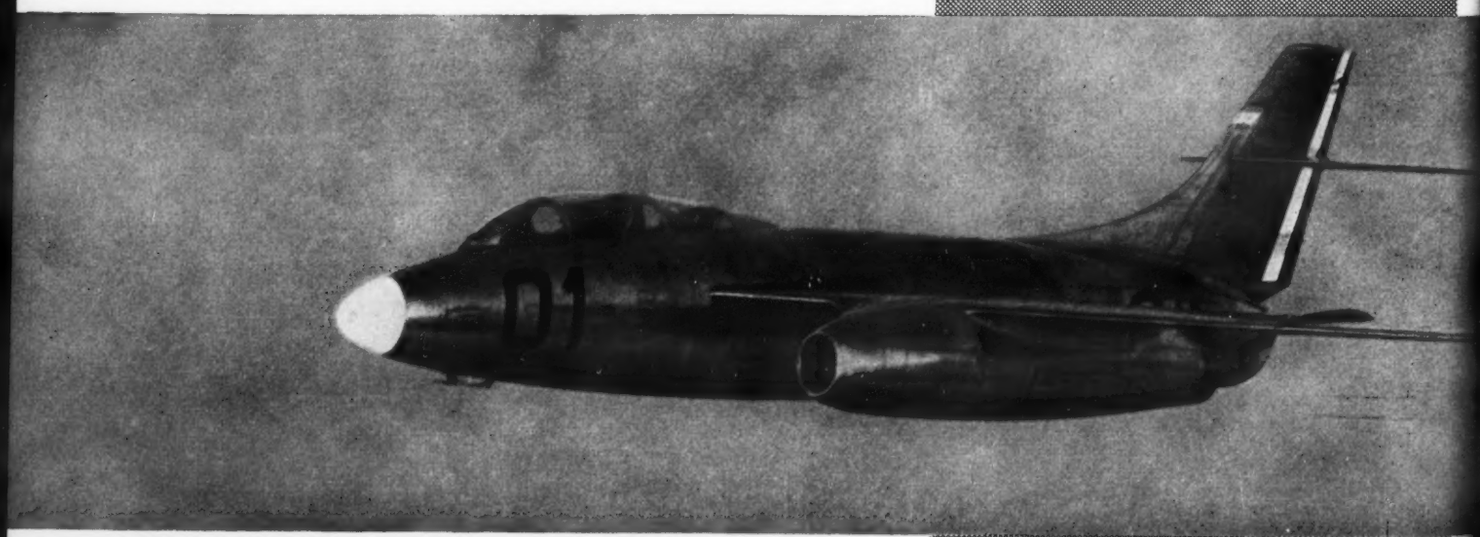
3 VERSIONS



All-weather fighter

Ground attacker

Bomber



SOCIETE NATIONALE DE CONSTRUCTIONS AERONAUTIQUES DU SUD-OU

105, AVENUE RAYMOND-POINCARÉ - PARIS 16e - Tél. KLEber 32-20

INTERAVIA

Deadline Notes

No. 8, 1954

NO "STANDARD TRAINERS" FOR N.A.T.O.

"It is beyond the competence of the N.A.T.O.'s Air Training Advisory Group to select standard aircraft for the training of N.A.T.O. air crew", France's Major-General Georges de Buretel de Chassey, Group Chairman, declared in Paris at the conclusion of a three-day N.A.T.O. training aircraft demonstration. The choice of suitable equipment was the individual responsibility of the various N.A.T.O. States, he added.

A tendency towards dividing training into three stages seemed to prevail among the delegates: the first with a primary trainer developed in the country itself, the second almost universally with the Fouga 170-R "Magister" basic trainer, and the third and last on an advanced trainer such as the Fokker S. 14 and the Fiat G. 82.

THIRD U.S.A.F. PILOTLESS BOMBER SQUADRON

The U.S. Air Force has formed its third pilotless bomber squadron, designated the 11th PBS. The squadron, equipped with Martin B-61 Matador bombers, is assigned to the Tactical Air Force at Orlando A.F.B., Fla. The 1st Pilotless Bomber Squadron is now on duty at Bitburg, Germany, and the 69th PBS is completing its operational training at Patric A.F.B. prior to deployment to Germany this autumn.

"CONILLUM" INSTEAD OF "BLACK-OUT"

The U.S. Joint Chiefs of Staff have approved a new plan designated "CONILLUM" (a contraction of "Controlled illumination"), which instead of a complete black-out requires a reduction in normal lighting by up to 75%. Black-out curtains will be superfluous since Venetian blinds or shades adjusted so that no light can be emitted at horizontal level or above will meet requirements. Exterior floodlights and advertising etc., would have to be restricted, however. "CONILLUM" is complementary to "CONELRAD" ("Control of Electro-Magnetic Radio"), the radio plan for denying radio bearings to hostile aircraft by beaming on radio station, under which all radio stations will transmit on very few, identical wavelengths.

U.S. SENATE APPROVES MILITARY CONSTRUCTION BILL

A $837,000,000 world-wide military construction programme for the 1954-55 fiscal year was approved by the U.S. Senate on July 15th. The compromise bill, which now goes to the House of Representatives for approval, is about $60,000,000 short of the appropriations originally requested by the Administration.

U.S.A.F. BASE IN LIBYA

The Libyan-U.S. agreement providing for the lease of military air bases in Libya has been signed. Similar to that between Libya and the U.K., it grants the use of bases to the U.S.A.F. for a period of 20 years, in return for economic aid. Main U.S.A.F. base at present is at Wheelus Field, three miles east of Tripoli.

SOVIET JETS FOR FINNISH AIR FORCE?

According to United Press, the U.S. State Department has approached the Finnish Foreign Ministry to ascertain whether or not reports concerning the purchase of Russian jet aircraft for the Finnish Air Force are authentic. Finland is said to be planning the acquisition of Soviet jet trainers; simultaneously it is rumoured that Finnish pilots are to be trained in Russia. Other sources claim that the purchase of MiG-15 fighters is also envisaged.

AIR A.D.C. TO QUEEN ELIZABETH

Air Chief Marshall Sir Arthur Sanders has been appointed Air Aide-de-Camp to Queen Elizabeth II.

T.W.A. ALSO SELLS "NEVER-NEVER" TICKETS

Like Pan American World Airways, Scandinavian Airlines System and Sabena, Trans World Airlines has introduced an airline ticket instalment plan: down payment 10%; 20 monthly instalments. The credi-

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plan is backed by Pacific Finance Corp. - Example: New York-Paris, tourist class, $47.00 prior to departure and $24.84 per month for 20 months.

U.K. AIRLINES CARRY 21% MORE PASSENGERS

United Kingdom airlines carried 2,188,000 passengers during the fiscal year to March 31st 1954, an increase of 20% over the previous year, the Ministry of Transport and Civil Aviation reports.

500th DOUGLAS DC-6/DC-7

The 500th airliner of the company's DC-6 and DC-7 series rolled off Douglas Aircraft Co.'s production line at Santa Monica on July 22nd. The series is the first basic post-war commercial type of any manufacturer to reach the half-thousand mark.

SPAIN'S A.E.C.M.A. BECOMES A.T.E.C.M.A.

A.E.C.M.A., the Association of Spanish Aircraft Manufacturers, has been renamed A.T.E.C.M.A., i.e., "Agrupacion Técnica de Constructores de Material Aeronautico".

ITALIAN INDUSTRY ASSOCIATION DEMANDS GOVERNMENT SUPPORT

At a Rome conference of A.I.A., the Italian Aircraft Industries Association, speakers stressed the fact that Italy's aircraft industry, with the personnel and resources now at its disposal, possesses all the qualifications necessary to participate in the supply of flying equipment which will be indispensable for the eventual European Defence Community. However, the Government is not furnishing the required support to the industry. Professor G. Gabrielli, Managing Director of Fiat, pointed out that the inter-ministerial programme elaborated in 1952 to provide work for the industry has never been implemented. In order to prevent a decline of the industry and the dispersion of highly qualified personnel, it is essential to provide a practical interim solution through the optimum utilization of production facilities, distribution of credits and the creation of a special organization to promote exports.

BOEING COMPLAINS ABOUT INSUFFICIENT PROFITS

John O. Yeasting, Vice President-Finance of Boeing Airplane Company, speaking to the Los Angeles Society of Security Analysts, stressed that the aircraft industry ought to have a larger profit margin than that allowed at present. Thanks to the expiration of the Excess Profits Tax, Boeing anticipates a rate of return on sales for the current financial year of between 3% and 31/4%, compared with 2% last year. Nevertheless, aircraft manufacturers still have to rely too heavily on government funds. Boeing Airplane would like to do more research and development with its own money.

*

WORKSHOP BRIEFS...

The Boeing 707 "Stratotanker/Stratoliner" piloted by the company's Chief Test Pilot, A.M. "Tex" Johnston, made its maiden flight July 15th. * The de Havilland "Comet III" prototype started its trial flights at the company's Hatfield aerodrome July 19th. * The first aircraft of the pre-production series of the Fouga CM. 170-R "Magister" trainer has started its flying trials at Toulouse-Blagnac. * The third SO. 4050 "Vautour" prototype has been completed and taken to Melun-Villaroche. When these lines appear in print the "Vautour 03", i.e., the bomber version, will probably have started its flying trials. * During a test flight the SE. 5000 "Baroudeur" jet fighter and ground attack aircraft reached supersonic speed. * The prototype Morane-Saulnier MS 760 four-seater jet propelled liaison aircraft has been completed. * Britain's Hymatic Engineering Company Ltd., has developed a new series of bleed valves, designated P.S. 48 for such applications as pressurizing fuel tanks to transfer or jettison fuel and to prevent fuel losses by boiling at high altitudes. They can stabilize inlet pressures of up to 200 p.s.i. at constant adjustable outlet pressures of up to 35 p.s.i. within temperature limits of -40°C to 250°C. * The Chilean Fabrica Nacional de Aeronaves FANAERO is building a single-engined wooden military and civil trainer, 125 h.p. engine. * Hunting Percival Aircraft has developed an armed version of the Hunting Percival "Provost" trainer, equipped with two .303-in. Browning machine guns mounted in the wings; alternatively, two 250-lb. bombs, six 60-lb. combat rockets, eight 25-lb. training rockets or eight 25-lb. training bombs plus four combat rockets can be carried. * North American Aviation is working on the design of a new stripped fighter. * Etablissements Faure-Herman, of Boulogne-Billancourt, has sold the manufacturing rights to its electro-magnetic fuel-flow meter to H.M. Hobson, Limited, Wolverhampton.

* * *

Field-Marshal Montgomery Reports:

"... Both Sides would Probably Use Atomic Weapons..."

A study of the official and semi-official documents—reports drafted by committees of experts and information published by the press—shows that though the existence of "nuclear" weapons leads to but a slow evolution in arms design, very little concerning the potentialities of atomic weapons has been concealed from the public. Perhaps never before has a new weapon of such capital operational importance been perfected and even set up as instrument of a possible future conflict in such a glare of publicity. As the object was to use it as a bogy to discourage a third world war, it was important that its character should be as widely known as possible. Parallel to the technical race being run in secret, there is an open rivalry in intimidation, with the atomic weapon being used to balance the tremendous combat potential of the Soviet *bloc*.

The reader of all this literature—whether it be the report of the Atomic Energy Commission on the effects of atomic weapons, the book by Colonels Reinhardt and Kintner ("Atomic Weapons in Land Combat"), Colonel Ailleret's writings on the H-bomb or Colonel Genaud's on atomic weapons—cannot help but be sceptical about the possibility of such means of destruction ever being used. Though the effects of an individual atomic projectile can still be "absorbed", the cumulative effect of a rain of atomic bombs is unpredictable. Could the nation or nations involved withstand the impact of a conflict? Up to the present men had reasons to hope that in the event of war, as S. Weingard writes elsewhere in this issue, many of them would be able to "walk between the drops of steel of the rain of bombs with conventional chemical explosive." Since Hiroshima and Nagasaki and the successive Bikinis and Eniwetoks, the situation has changed. We are all in the same boat, drifting along with the threat of all being thrown into an atomic whirlpool.

During a recent interview Field-Marshal Viscount Montgomery said: "My opinion is that the fear of atomic weapons is a powerful deterrent to war; but, so far as we can see today, once war has started both sides are likely to use them." He adds: "To me one thing is clear–in any future war a great battle will rage in the air, but we must also be prepared as in the past for battle on land . . . We are now approaching an age of tremendous scientific progress. When atomic and thermo-nuclear weapons appeared on our horizon, the world 'dispersion' immediately became important—not only in the tactical sphere but also in the national means for waging war."

These words should be taken as a guide to any study of a possible future atomic war. Once again they give priority to the air arm, they put the accent on a new factor, dispersion, but a dispersion organized on the same scale as the havoc wrought by atomic weapons and hence a very different affair from that of the past.

Lord Montgomery continues: "An army must always be prepared mentally for new types of weapons and for the changed conditions which they bring about. The emphasis must be on tactical conceptions and weapons systems. We must not make the error of employing the weapons of today, or of the future, under the tactics of a previous war . . .

"Any suggestion that the introduction of atomic and thermo-nuclear weapons is not going to affect the organizations of armies, and the tactics of land warfare is nonsense. We must examine our armies, and their equipment, to see what changes are needed in an atomic age. A complete reorganization is needed of the reserve armies of all the N. A. T. O. countries, both in continental Europe and in overseas countries; the present systems for producing reserve armies are out of date . . ."

The Depuy Supreme Allied Commander, Europe, has thus clearly defined the problem of the evolution—which might become a revolution if speeded up—in existing military equipment, on both sides, to keep pace whith the piling up of atomic weapons and with our increasing knowledge of the effects of these weapons of mass destruction.

This does not mean that the present *modus vivendi* will not be maintained for a long time to come. But perhaps it can only be maintained to the extent to which the progressive transformation of the armed forces called for by the victor of El Alamein is put into effect. *E.E.H.*

CRESCENDO OF DESTRUCTION
(Number of killed and main weapons in wars of the past six centuries)

"Dulce bellum inexpertis"
War is sweet—to those not acquainted with it—
Erasmus of Rotterdam

Year	Battle or War	Killed	Main Weapons
1346	Crécy (Hundred Years War)	38,000	Six bombards with stone balls, arrows, lances, maces.
1515	Marignano (France v. Milan)	34,000	Cannon, arquebuses (first rifles), lances.
1709	Poltava (Swedish Wars)	10,000	Cannon, muskets
1756—63	Seven Years War	240,000	Cannon, muzzle-loading rifles
1861—65	American Civil War	118,000	Cannon, rifles
1870—71	Franco-Prussian War	120,000	Cannon, breech-loading rifles, few small machine guns
1904—05	Russo-Japanese War	115,000	Cannon, machine guns, rifles (trenches)
1912—13	Balkan Wars	350,000	Cannon, machine guns, rifles
1914—18	World War I	10,000,000	Cannon, tanks, bombs up to 1,000 lbs.
1939—45	World War II	14,000,000	Cannon, tanks, bombs up to 10 tons, two A-bombs equivalent to 20,000 tons.
?	World War III	?	A-bombs equivalent to 20,000 to 200,000 tons explosive, H-bombs 10,000,000 to 50,000,000 tons equivalent...?

The figures for the battles and wars up to World War I are estimated values based primarily on "Losses of Life Caused by War," by S. Dumas and K. O. Vedel-Petersen; published by the Carnegie Institute, Oxford 1923.

N.A.T.O.—2

"THE BOMB" on Men and Cities

BY S. WEINGARD, STUTTGART

"All are aware that the war potential that either side may mobilize is such as to make another war absolute madness, much more so than the madness which led to the two world wars."

FIELD-MARSHAL SMUTS AT CAMBRIDGE UNIVERSITY, JUNE 11TH, 1948

"The age of big cities is past," says U.S.Civil Defense Administrator Val Petersen. An H-bomb of "only" 10 megatons (there is already talk of 40 megaton thermo-nuclear projectiles) [1] would demolish a modern city over an area of some 50 square miles (130 km²) and its environs, and render it uninhabitable over an area of some 385 sq. miles (1,000 km²). Radio-active rain would still be injurious more than 90 miles (150 km) from ground zero, particularly downwind from the city.

If the 67 major cities in the United States were subjected to a surprise attack by hydrogen devices equivalent to the one which caused an islet in the Pacific to disappear, 22 million persons would be seriously injured and 9 million killed. "How," asks Val Petersen, "could we bury nine million dead?" And as there would be immediate retaliation, the aggressor would be confronted with a problem at least as serious. With the prospect of such a general massacre, which might remove close on a hundred million persons from the face of the earth in a few hours, it seems inconceivable that these weapons should really be used.

Nevertheless, thousands of experts are studying the possible influence of a mass hydrogen-bomb attack on population, industrial and economic life of the nations (see diagram I).

The destructive effects cited above have been carefully examined. Obviously nothing would be left standing within a radius of 2½ to 3 miles (4 to 5 km) of an H-bomb explosion. Such a blow would suffice to wipe out 95 % of a big city. But because of the screens afforded by the terrain, by the buildings themselves and by specially constructed shelters, the population would not all be killed at this distance. The extent of radio-active effects would depend on the conditions of the explosion (overhead, on the ground or below ground), the direction of the wind and the amount of protection. With sufficient warning, intensive training and a strong anti-atomic organization, the effects of the H-bomb can be considerably reduced. But this meagre hope immediately renders an atomic attack possible again. The attractions of war will outweigh the horror it inspires. If there is a chance of surviving an atomic attack and if the stake in an H-bomb conflict is big enough, the supreme risk may well be taken.

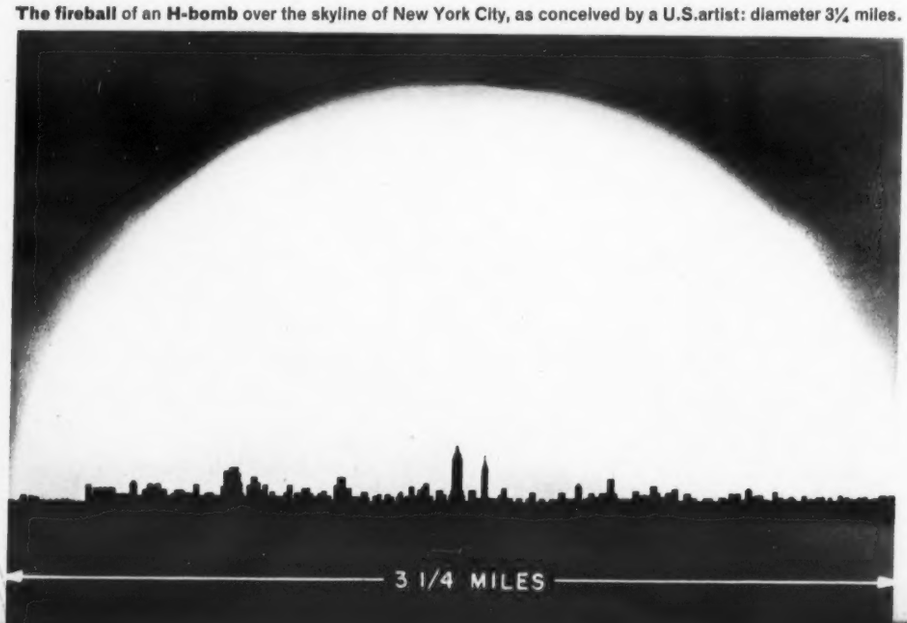
The first thing any anti-atomic civil defence organization needs to know is how much warning it can count on. In the United States, a country protected by vast oceans and land masses, estimates vary between one and two hours. If the attacking bombers are at less than 4,500 ft. (1,500 m) when they cross the radar areas, it is very difficult to detect them from a distance. With "low cover" and a perfect radar

Val Petersen, U.S. Federal Civil Defense Administrator, termed the first U.S. H-bomb explosion of November „an awesome turning point in our history."

detection belt, the warning period could be lengthened. But how can this electronic Wall of China be set up at sea, along the east and west coasts of the New World, except by patrols of radar aircraft operating constantly along the coasts, and by detection vessels stationed at sea? A U.S.—Canadian programme is reported to aim at extending the detection belt over some 17,500 miles (28,000 km). At least three hundred radar stations would be needed, operating 24 hours a day, and they would have to have detection aerials for high, medium and low altitudes. From Florida to Newfoundland (3,000 miles or 5,000 km), from California to the Queen Charlotte Islands (4,000 miles or 6,000 km) ships and aircraft equipped with early warning radar would have to be constantly on duty over the oceans, checking aircraft movements over hundreds of miles, if the warning available to coastal cities is to he increased. On the other hand Russia, more effectively covered by land masses and with few coastal cities, turned inwards for centuries past towards the heart of the continent and turning her back on the enclosed seas which geography and international politics have combined to give her, is

[1] 40 megatons is the equivalent of 40,000,000 tons of T.N.T.

The fireball of an **H-bomb** over the skyline of New York City, as conceived by a U.S.artist: diameter 3¼ miles.



in a better situation than North America as regards length of warning.

The United States Civil Defense Administrator estimates that it would take two to six hours to evacuate each of the large cities on Federal territory. This, of course, would not apply to cities such as New York or San Francisco, surrounded by water and connected to the mainland by bridges which would form bottlenecks not exactly calculated to facilitate hurried evacuation. And even for cities in a better geographical situation evacuation can be envisaged only if billions of dollars have first been spent on roads, bridges and shelters, and on condition that the population has taken part in numerous exercises and is not seized with panic the moment the warning sounds.

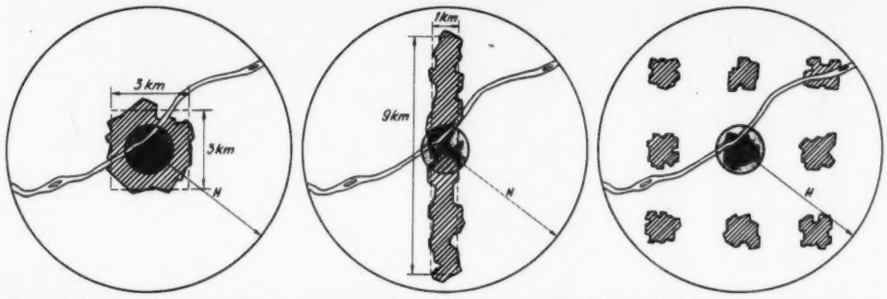


Diagram 1 However attractive the linear plan for future cities may appear, it does not stand up to close analysis. The drawings show three suggested plans for a city of 150,000 population, covering an area of 3½ sq. miles (9 km²). **Left:** a 20-kiloton A-bomb exploding 2,000 ft. (600 m) above the centre of the city would destroy about 30% of the built-up area. Six bombs would be needed to knock out whole city. — **Centre:** If the same city were built on a linear plan, the same bomb would destroy a **minimum** of 13% of the city, and ten bombs would be required for total destruction. **Right:** the best solution is offered by a "cell" plan, for example nine cells of about .4 sq. miles (1 km²) each. Here one bomb would destroy a **maximum** of one-ninth of the city. Making allowance for aiming errors, it would take more than ten atomic bombs to wipe out the city.

It has been calculated in the United States that it would cost more than $500,000,000,000 to rebuild the threatened cities to meet even the 20-kiloton A-bomb threat. Even these plans would be useless against an H-bomb. (Outer circle marks the range of destruction of the H-bomb.)

Panic, handmaid to the bomb

The money can always be found, and an organization that would be theoretically efficient created. There remains the problem of panic. The city-dweller will be faced with the certainty of being killed if he cannot get to proper shelter in time. In the age of the chemical bomb, even when *Lancasters,* B-17s, B-24s and B-29s were raining down H.E. and incendiary bombs on Berlin and Tokyo, the inhabitants of these cities still had a chance of walking between the drops of steel that showered down from the sky. This is no longer true today. Experience of major disasters, such as tidal waves, volcanic eruptions, earthquakes, fires, explosions of ammunition dumps, etc., shows that in such circumstances man barely remains master of himself. Centuries of civilization and years of individual training are brutally swept

The H-Bomb Threat to Cities

I. Protection measures for existing cities

Preliminary conditions:

Solution No. 1 — Evacuation

- Warning of 2 to 6 hours, depending on country and city plans.
- Complex civil defence organization.
- Frequent collective training.
- Panic controlled.

Result

If successful, practically all the threatened population could be saved.

Solution No. 2 — Protection in city

- Warning of 15 mins. to an hour.
- Simpler civil defence organization.
- Relatively limited training.
- Smaller risk of panic.

Result

Even if successful, heavy losses would be probable.

Common requirements

- Large sums of money.
- Stocks of food, clothing, medical supplies etc., in safe places, outside the city for evacuation, underground for use in the city.

Special measures

- Clearing of major thoroughfares, opening of roads radiating from the centre towards the outskirts and widening as they go. Creation of underground exits.
- Construction of a new network of wide roads, connecting up with the main thoroughfares.
- Organization of tented reception towns etc.
- Grouping of the resources required for life and for continuing the war, in the neighbourhood of the satellite cities.
- Construction of shelters, adaptation of existing underground installations, equipment of caves, provision of stocks of medical supplies and rations protected from radiation.
- Provision of fire-fighting, decontamination and general safety equipment in shelters.
- Construction of protected communications systems.
- Advance provision of vehicles for clearance and repair work.

II. Town planning in the atomic age

Combination of effects of dispersion and local protection by new kinds of cities

- linear plan for future towns.
- construction of shelters for each group of buildings.
- public installations (markets, stations, garages, banks, museums, key authorities) underground.
- development of underground means of transport for local protection and rapid evacuation to the country.
- development of suburbs and dispersed residential areas.
- decentralization of principal industries.
- electric cables, water mains etc. to be placed deep underground.
- adoption of a new type of construction (e. g. "earthquake houses" of Japan or California).
- Use of new materials.
- Supply of fire-fighting, anti-radiation, repair equipment etc., to meet the possible scale of damage.

away. The individual passes from the human or national level to the family or even personal level. Civil defence services risk being paralysed because their personnel first look after themselves or the persons dear to them before carrying out their duties. Or fear may be so great that individuals remain frozen on the spot awaiting their fate, too stricken to escape the blast or heat wave. If evacuation succeeds in part, several days will pass before the scattered population can recover sufficiently to take part again in civil defence measures. Even during World War II there were certain "conventional" raids where those who had managed to flee remained tens of miles away for days from the target attacked (cf. diagram 2).

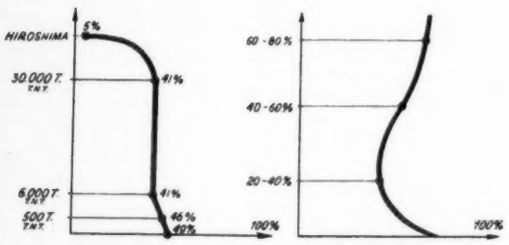


Diagram 2 — Effects of air raids on morale. In his "Strategic Air Power" Stephan Possony studies the effect of air raids on the morale of the population, based on information from Germany and Japan. The left-hand curve shows the population's will to resist, *in* percentage of the population considered, plotted against the weight of bombs dropped. It shows that, even in cities not attacked, the percentage of the most determined does not exceed 49%.—The right-hand curve shows the percentage of houses destroyed and the morale of neighbouring populations not attacked. Beyond a certain point, morale rises rather than follows the increase in destruction.

In Europe the problem is even more complex. Here population movements would be double. On the one hand, there would be the hurried evacuation of large towns, involving a movement from the centre towards the outskirts, and on the other the usual falling back from the threatened frontiers towards the interior. It follows that at any rate part of the environs of the cities would be the scene of opposing movements, the source of bottlenecks, disorder and panic (diagram 3).

Whatever the sums spent, the preparations made and the organizations set up, it is doubtful whether any nation could stand the "atomization" of several of its larger cities. It may be objected that by dropping only 1,700 tons of bombs on Tokyo on March 9th, 1945, American B-29s killed 83,600 persons and wounded 102,000 without causing Japan to surrender. Five months later, the *Superfortress* "Enola Gay" released the 20-kiloton bomb over Hiroshima (80,600 killed, 70,000 injured) and stopped hostilities. But it was clear that there could be no defence against an isolated aircraft, which created more damage than a fleet of several hundred. Moreover, as at that time the population of Tokyo was four times as dense as that of Hiroshima, an A-bomb dropped there would probably have killed nearly 320,000 people. Alone the threat of a much vaster holocaust (since destructive power has been multiplied by at least 500) might decide the belligerents, at any rate at the outset of a conflict, to agree tacitly to limit use of A-weapons to the battlefield or to strictly military targets in the front line.

* * *

The battlefield prepares to withstand the bomb

It takes two years of intensive training in atomic exercises, if not to familiarize the ordinary soldier with atomic warfare, at any rate to teach him to protect himself against some of its effects. Men will never feel comfortable in an area where the blast wave produces an excess pressure of 57 p.s.i. (4 kg/cm²), the heat wave an increase in temperature of more than 26 calories per square inch (4 cal/cm²) and the radioactive rain exceeds 200 roentgens per hour in intensity[2].

But after months of investigation and experiment with guinea pig units, the experts have arrived at the following conclusions: man reacts better than had been expected to the "treatment" inflicted by atomic bombs (the human body can withstand brief periods of excess pressure 20 times as great as would bring down a brick building); he can be trained to atomic warfare, and finally land forces can adapt themselves to this immeasurable increase in the power of destruction which directly threatens them.

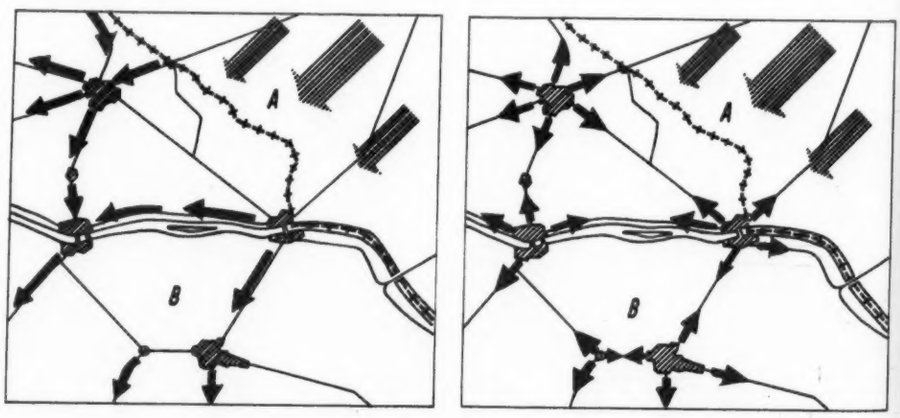
The table below gives the critical distances below which infantry without cover would sustain such heavy losses that effective continuation of the battle would be impossible (air bursts).

	A-weapons			H-weapons
	20 kt	40 kt	150 kt	10 mt or 10,000 kt
Blast	2,000 m	2,500 m	3,500 m	16,000 m
Heat	2,500 m	3,200 m	5,500 m	35,000 m
Radiation	1,000 m	1,200 m	1,800 m	2,500 m

Trenches very similar to those of 1915 to 1918 would again provide essential protection. However, atomic warfare experts now envisage only individual foxholes, so that troops can maintain their mobility. If an A-bomb explodes 2,000 ft. (600 m) above ground, a foxhole 6 to 7 ft. deep 600 yards from ground zero would suffice to protect a man from blast, heat and even radiation. Admittedly radiation intensity at 600 yards is still in the region of 10,000 r, but some 2ft. 6ins. of earth on the edges of the trench are sufficient to reduce radio-active effetcs to $^1/_{64}$ th of their initial strength, i.e., to less than 200 roentgens, a dose that is not fatal. This type of foxhole protection was already used in Korea, against napalm attacks. The experiments carried out in the United States, particularly those during exercise "Flashburn", show that vulnerability of troops, arms and

[2] A roentgen is the unit of intensity of gamma rays.

Diagram 3 — Evacuation problems: In the pre-atomic age (a) the general direction of evacuation was decided by the direction from which the enemy approached. The same would probably apply in an atomic war. However, this general movement would be complicated by a tendency towards radial evacuation of cities (b). In certain sectors on the outskirts of towns (north and east in the diagram) the two movements would collide and add to the confusion.



equipment to the 20-kiloton A-bomb is as follows, starting from ground zero:

Tanks, as such, could approach the closest to ground zero, but their crews would be decimated by radiation long before; then comes artillery, heavy wheeled vehicles, semi-buried ammunition dumps. Man comes next, provided he is in a deep trench. A little further away, he can survive in a foxhole and still further away he is safe in open country if properly equipped. At a greater distance from ground zero, i.e., between 800 and 1,000 yards, is an area where the combined effects of heat and blast would demolish delicate equipment such as electronic fire control and surveillance radar equipment. Needless to say, as destructive power augments, from 20 kilotons to 10 megatons, the critical distances considerably increase, up to for example something like 20 miles (30 km) for unprotected personnel.

How the infantry can meet the threat

What are the strategic and tactical effects of the introduction of atomic weapons on the battlefield?

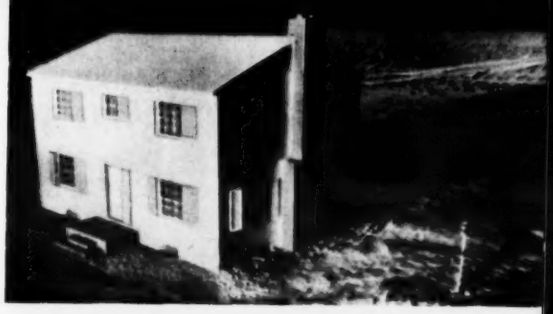
In their outstanding book on land warfare in the atomic age, Colonels G. C. Reinhardt and W. R. Kintner[3] conclude that, unlike pure air warfare, atomic land combat gives the defence certain advantages over the offence.

As soon as one opponent, in order to conduct his offensive, must concentrate his forces to give them mobility, he becomes vulnerable to enemy atomic attack, while the defender, dug in or widely dispersed, can more easily escape attack. This relationship between concentration and dispersion will be at the basis of atomic land strategy. Each of the belligerents will seek to reverse it in his favour. In order to succeed, he will play on the decentralization of his forces (defence against atomic attack) and their extreme mobility (ability to concentrate so as to pass from the defensive to counter-attack) without offering for too long a worthwhile target for the enemy's aircraft or atomic missiles.

A conventional infantry division deployed on a front of 6 miles (10 km) ready for an offensive is highly vulnerable to atomic attack, even if the latter uses only so-called "moderate" power projectiles (20 kilotons). One A-bomb would probably suffice to put the whole unit *hors de combat;* not that it would be entirely wiped out, but it would be so disorganized that regrouping would take time. Three A-bombs would eliminate the unit as a division from the order of battle. When in defensive position, that is, dug in and dispersed, the infantry division is less vulnerable, and it is estimated that at least twice as many A-bombs would be

[3] *Atomic Weapons in Land Combat.* — The Military Services Publishing Co.

"Men will never feel comfortable in an area..."—Pictures show complete destruction of a test house located 3,500 ft. from "ground zero" during A-bomb tests in Nevada in 1953: **a**: The test house bathed in light from the atomic blast; **b**: The house is set aflame by the intense heat; **c**: Subsequent shock waves extinguish most of the fames; **d**: The house begins to disintegrate; **e**: Sections of the house are driven through the air; **f**: Clouds of dust combine with the splintered pieces of stone and lumber.—Time from **a** to **f**: 2½ seconds.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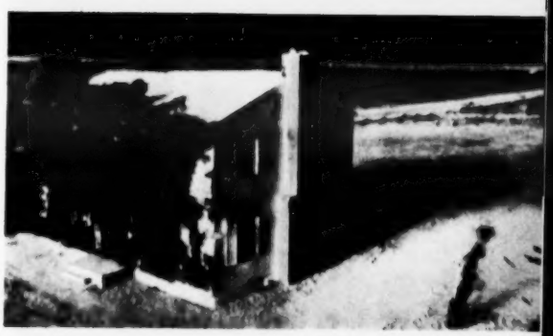
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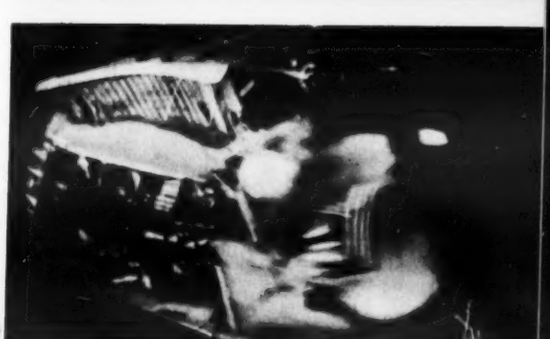
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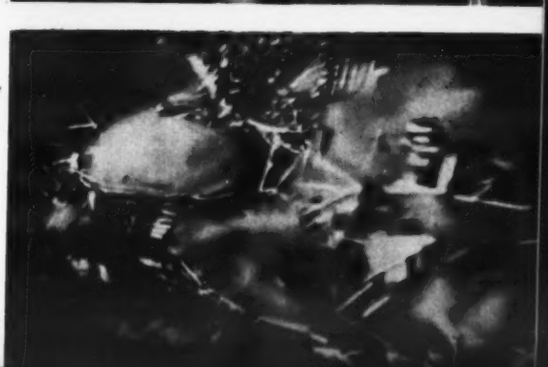
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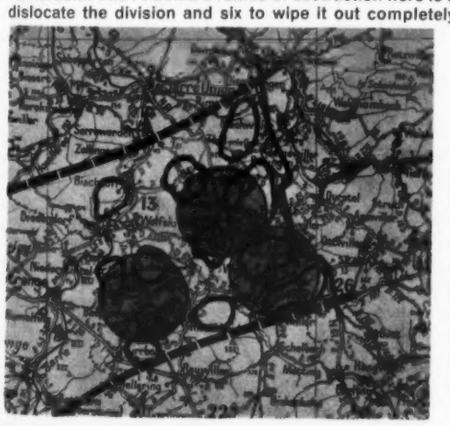
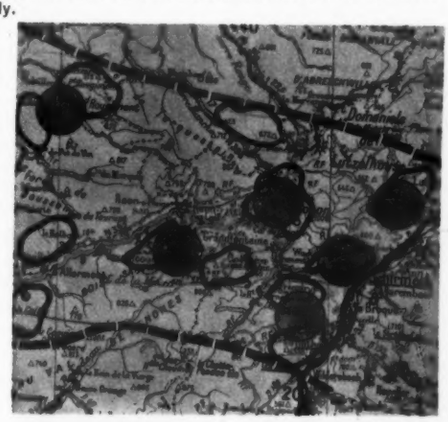
Diagram 4 Vulnerability of land forces in offensive and defensive: In the offensive position (a) the unit is more concentrated. Its manpower and equipment are ready for operation and are consequently deliberately without cover. The radius of destruction of an A-bomb is 2,000 m. Two bombs would render the whole large unit useless. Three would remove it completely from the order of battle.

In the defensive position (b), in more broken country and with its units dispersed and dug in, the division is less vulnerable. The A-bomb's radius of destruction here is 600 m. In this case it would take at least three bombs to dislocate the division and six to wipe it out completely.





needed to wipe it out from the order of battle (see diagram 4).

However, experts in atomic warfare agree that large land units must be very different from those which distinguished themselves in World War II. They wish to retain the same fire power but reduce personnel strength. They aim at motorizing all divisional units, so that the new large unit can disperse or concentrate rapidly to suit the phases of atomic warfare. Supply bases will therefore have to be in the rear, and a road, or better air, shuttle service be organized to bring up the rations and ammunition required in combat. And because of the stress that must be laid on the transport of troops and supplies, land forces come to the point of basing their survival in the atomic age on the mass employment of air equipment such as the helicopter and the transport aircraft. The taxis of the Marne and their wheeled or tracked successors have been relegated to the past, to be replaced by rotary-wing aircraft and assault transports.

The experts thus consider that after lengthy experiment and almost complete reorganization of the classic structure and employment of its units, the army can adapt itself to atomic warfare. They add two conditions: ground and air equipment must be sufficiently mobile; the army must be backed by an A-bomber force, itself but slightly vulnerable to enemy attack, especially at its bases.

At present the fighter-bomber and light bomber units which would be employed to drop tactical atomic bombs are still equipped with aircraft designed for non-atomic warfare and are so vulnerable on their bases that the authors of *Atomic Weapons in Land Combat* are worried at how much support they could provide for the land forces. An atomic bomb exploding on the ground near the centre of a concrete runway would make a crater so large that it would be better to make a new runway elsewhere than attempt to repair the old one. And the mass of radio-active soil thrown up into the air would fall back and knock out anything on the aerodrome that had escaped the atomic earthquake. Atomic weapons, write Colonels Reinhardt and Kintner, could make land bases as vulnerable as their naval counterpart, the aircraft carrier. But whereas the aircraft carrier cannot be divided into "small pieces" until vertical take-off aircraft become utilizable in combat, land-based fighter-bomber squadrons could be equipped with machines capable of using fields less easily detected and less vulnerable than their present runways.

Infantry can adapt itself: U.S. troops watching the explosion of a tactical A-weapon a the Nevada testing grounds.

This is what engineers and military staffs are working on, both army and air force following the new rule of the atomic age, never to create a target which might justify an atomic attack.

If the effects of mass atomic raids on both front-line forces and the resources of the rear are added together, it will be seen that the lessons of the past are now of very little value. Will not the destruction of a few cities immediately lead to the evacuation of others, and hence to a breakdown in the administrative, economic and military life of the nation attacked? If an H-bomb, capable of cleaning out 800 to 1,200 square miles of battlefield, is launched on the front line, and if the units deployed in this area are surprised without cover and annihilated, will neighbouring sectors continue to hold forces ready to move and concentrated for a counter-attack? Here the human factor is the decisive one, and any forecast would be daring. The feeling of risk diminishes with familiarity. But is it possible to train millions of men in the game of atomic warfare? Will not surprise always play its part, paralysing the most carefully-planned organizations and outwitting all military calculations? The main feature of this type of war is that it would be different from all others, that we have no experience of it and that such experience is most difficult to acquire.

A New Science:

Analysing the "Atomic sensitivity" of a people

INTERAVIA STUDY GROUP

Vision of things to come? The gambling clubs of Las Vegas, Nevada, in the unearthly glare of an atomic bomb exploded before dawn on May 7th, 1952, over Yucca Flats, many miles from the city.

At Strategic Air Command headquarters in Nebraska, as at those of the new Russian strategic air force, two groups of men study the elements of world strategy and inform their governments, on the basis of the conclusions they reach, on the conditions for peace or war. These men are experts on targets. Their task is to analyse the other side's vulnerability to atomic blows.

Up to the present relative strengths have been measured in terms of morale, will to resistance, individual potential, strategic reserves, air, land and naval forces available on the first day of war and resources mobilizable later. A nation's military power had been measured in the same way since time immemorable. The only change was the shift in efficacity of the various arms, with first place going to the air arm . . .

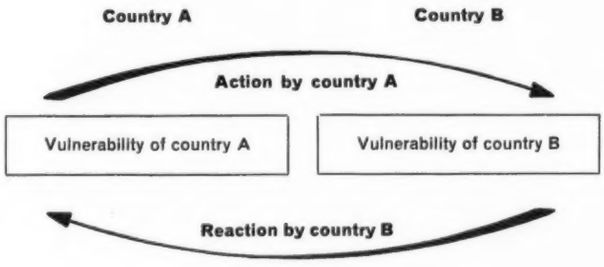
The A-bomb and, to an even greater extent, the H-bomb have completely overturned this conception. Three of the hypotheses enumerated in the accompanying box relate to atomic warfare. The implications of the last are the most serious, because of the surprise factor and the extent of the damage it would cause. Though it seems inconceivable that hostilities should break out, this would be the most likely hypothesis if they did. Either a third world war—an atomic one—is impossible, or recourse will be had to armed conflict only if all the following three conditions exist:

— the stake is of paramount importance; e.g., the very life of a nation is threatened;

— the chances of destroying the enemy's forces are almost 100%;

— and, above all, there is a high degree of protection against enemy retaliation, if such retaliation is judged likely.

The first of these three conditions is a matter for governments. The other two belong to the province of the military, who must decide whether these conditions are fulfilled or not. The analysis of the vulnerability of the two belligerents to atomic blows then becomes the decisive factor, since this is how the attacker measures his chances of success. The greater his own vulnerability to the retaliation which his attack can be expected to unleash, the greater must be his initial chances of success. The experts on targets and more generally on sensitivity to atomic blows must familiarize themselves with the old principles of action and reaction. A continuous cycle of action and reaction sets in, as illustrated in the diagram below:



The gravity of A's attack for country B depends on the vulnerability of B. In turn, the reaction of country B depends on the efficacity of A's aggressive action, i.e. the strength of the attack and B's vulnerability to blows. Finally the results obtained by B's retaliation depend again on the vulnerability of country A to the reaction it has provoked. There thus develops a continuous cycle composed of a number of factors, each of which depends on the preceding one. However, the cycle will not continue for very long. Because of the destruction caused by atomic weapons and the present organization of homes, industry and administration and the general life of the nations, it is impossible to imagine an atomic conflict lasting any length of time. The struggle may continue afterwards, in one form or another, but the list of targets worth an atomic attack will be

If a third World War broke out, it might be . . .

. . . a conflict in which no atom bombs were used or any of the destructive forms of atomic energy applied.

. . . a war begun without atomic weapons but in which one of the two sides came to use them later, either to hasten victory (as in the case of the 1945 attack on Japan) or to redress a desperate situation.

. . . a war in which discrimination is made between the targets susceptible to atomic attack, with atomic missiles, shells, etc. being used only on the battlefield and not against targets in the interior.

. . . a conflict which opens with a massive atomic attack directed simultaneously against the sources of the enemy's power, his atomic stockpiles and his air, land and naval forces.

(Hypotheses put forward by B. Brodie. The fourth is the one accepted by Field-Marshal Lord Montgomery.)

exhausted fairly quickly, and the atomic phase of the war will be halted, either temporarily or permanently, not for lack of manpower but for lack of targets.

All the complex factors which enter into the cycle described above can be evaluated. In addition to the efficiency of the offensive air forces of country A to begin with, and then of country B, the study of vulnerability to atomic blows takes on major importance, since it is the latter that conditions the results which the belligerents can justifiably expect of their respective air forces.

The threat to the air forces

During World War II attack on enemy air forces on their bases was not given high priority amongst the list of targets. A study of the United States Strategic Bombing Survey shows that less than 5 % of the bombs dropped by the 8th, 15th and 20th Army Air Forces were aimed at enemy airfields. Destruction of aircraft in flight was still rewarding, and it was thought preferable to wear down the enemy's air power at its source by destroying his aeronautical production capacity, while at the same time destroying part of industry and residential areas and undermining morale in the rear. Where Germany was concerned this concept was not entirely justified by results. Today with the inadequacy of air defences on the one hand and the overwhelming power of the atomic bomb on the other, the situation is quite different.

Commenting in the *New York Times* on what he calls the "New Look in Defense," Hanson W. Baldwin, the military critic, published the accompanying map. It shows that the defensive organization of the United States and the Western world is founded on 147 air bases round the Sino-Russian *bloc*. These 147 bases are distributed from Greenland to British Guiana, and from Newfoundland to Hawaii. If we add to these the airfields in the United States itself and those that are used exclusively by the United States' allies, the number of bases housing modern retaliation equipment or capable of being used for the take-off of the latter would probably come up to about a thousand. This provides a very considerable dispersion, which reduces the chances of success for any atomic attack on the Allied air forces. On their side, too, the Russians similarly seek to disperse their atomic air forces. If country A were the aggressor, he would have to add to the number of occupied airfields to be destroyed in country B the normal percentage of errors due to inaccuracies in aim and allow for the aircraft which would be shot down before reaching their target. He would then have to compare this total with the supplies of atomic bombs available to him for the operation. He would then be able to judge his chances and evaluate the strength of the retaliation his attack would provoke. As stocks increase, the two adversaries will doubtless increase the dispersion of their offensive air forces so as to render their complete destruction impossible. The "arms race" would take on a new form. It would aim less at increasing the number of squadrons than at distributing them over the face of the globe.

The threat to the rear

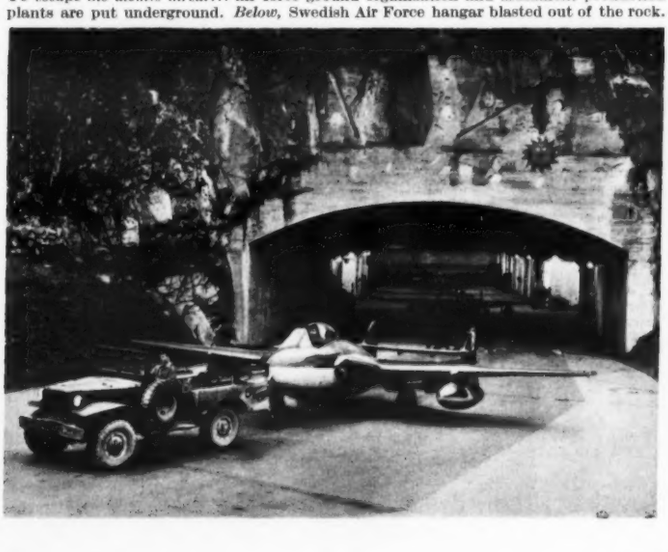
This is certainly an easier threat to wield, since it is aimed at targets which have come down to the atomic age from the past. These targets were not designed so as to escape destruction and are virtually impossible to adapt to the new forms of threat. Towns will not be moved underground, ports will not extend their docks over a hundred miles, and industrial installations will not break up into so many small units that they would be too much for available stocks of A-bombs. What may be called the "degree of urbanization" of a country provides a general criterion of its vulnerability. But local residential conditions form an additional factor. European cities and the construction methods generally followed would need far more bombs than Asian cities. Experience of World War II in Germany and Japan shows that whereas 1,000 tons of T. N. T. bombs were needed to destroy one square kilometre of a Western European city, one fifth of this tonnage was sufficient to produce similar damage in Asia.

Boss of America's A-striking force: General Curtis E. LeMay, 47-year old Commander of the U.S.A.F.'s Strategic Air Command, who has held his post for more than five years. He is a flying general who has logged more than 9,000 hours in everything from early biplanes to the giant Convair B-36 and Boeing B-52.

Today, the United States has

— 6 cities of over 1,000 000 population,
— 32 cities of over 250,000 population,
— 60 cities of between 100,000 and 250,000 population.

To escape the atomic threat... air force ground organization and armament production plants are put underground. *Below,* Swedish Air Force hangar blasted out of the rock.



Workshop of the Swedish engineering firm, Bolinder-Munktell AB, at Eskilstuna (this firm already had underground production facilities during World War II).

This map, published in "The New York Times" by the paper's well-known Military Correspondent, Hanson W. Baldwin, shows the location of the 147 air bases at the disposal of the U.S.A.F. outside the United States in the event of war.

These 98 cities have a total population of approximately 46 millions, or 29 % of the whole population of the country. This is a high degree of concentration, though less high than in Great Britain. The number of atomic projectiles required to destroy these 98 cities and with them a large part of the 29 % of the American population which they house is no more out of proportion to the obtainable atomic stocks than is a direct attack on the air power of the country. Certain cities, such as New York (which spreads over 370 sq. miles, or 950 km²) or Los Angeles (405 sq. miles, or 1,050 km²) would need several A-bombs. But if two thirds of a city is destroyed, that city no longer contributes to the life of the country but becomes a heavy burden beyond the capacity of the unaffected areas to bear. Russian towns will doubtless have a similar vulnerability, but they are further from the frontiers and hence less easily accessible.

Western Europe, including the British Isles, is naturally less well equipped to withstand an atomic attack directed against its large cities. Here there are 225 cities with a population of more than 100,000, making a total of some 75,000,000 inhabitants, or 27 % of the total population. There is an average of 28 cities of over 100,000 population per million square kilometres, whereas the corresponding figure for the United States is 12. The case of Britain and Western Germany, with their highly concentrated population and industrial centres within a relatively short distance of the Iron Curtain is even more critical. The closer targets are, the greater can be the speed of missiles and the more difficult they will be to intercept. Nearly 2,300 V-1s reached London, and 1,230 of the 4,300 V-2s launched against the capital fell within the London area. A wastage of 72 % is permissible when five A-bombs or one H-bomb on a target can cause irreparable damage.

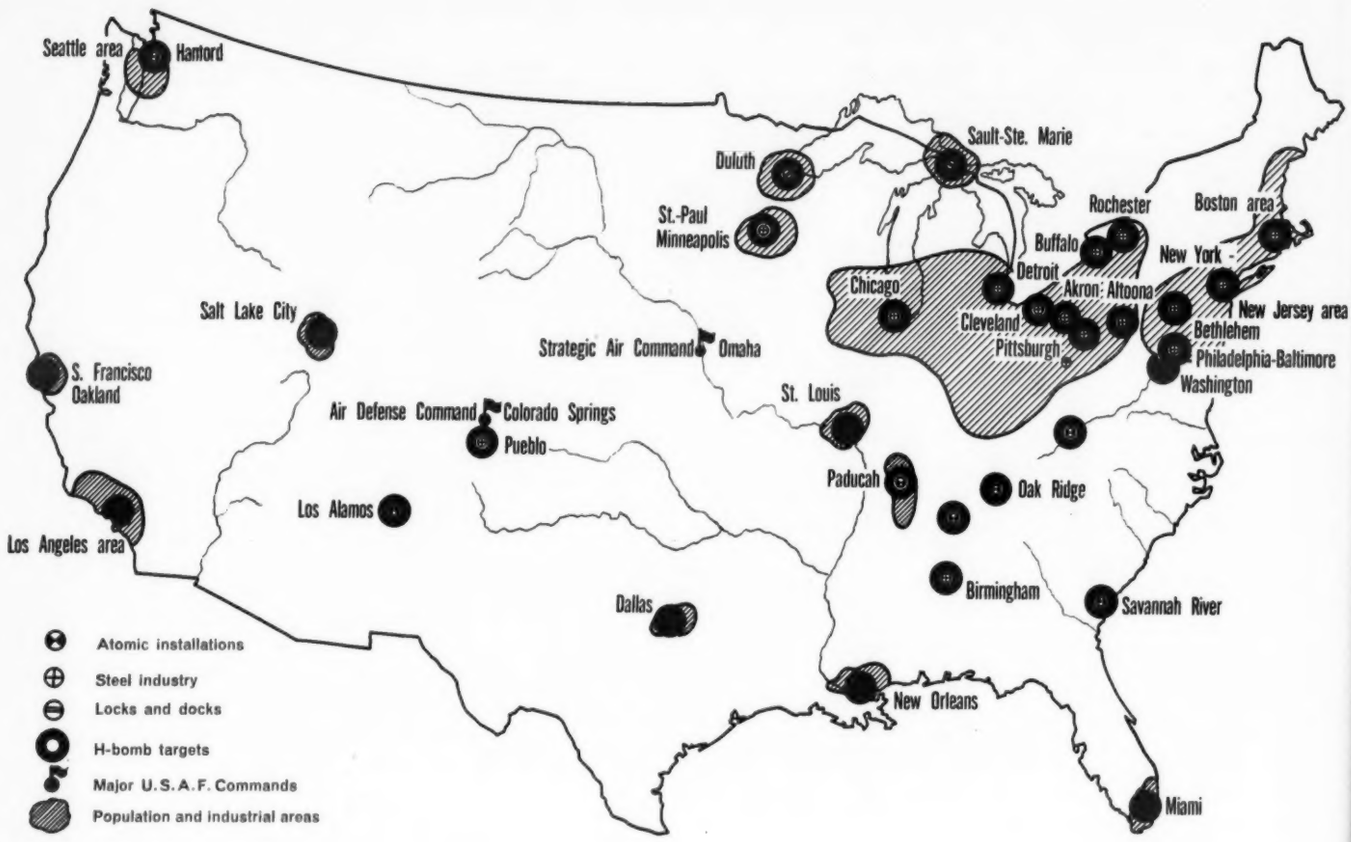
Built-up areas in Germany in 1942 totalled roughly 9,700 sq. miles (25,000 km²). About 1,300,000 tons of bombs were dropped on the territory of the Third Reich, 75 % of them on towns covering a total of 5,300 sq. miles (15,000 km²), the mean theoretical tonnage was less than 100 tons per square kilometre. In fact, the attack was concentrated on some fifteen cities providing 25 % of the national production. For example, Hamburg had 900 tons of bombs per square kilometre and Berlin 600 tons. It has been calculated that if it had been desired to extend the relative damage caused in Hamburg to the whole of Germany, it would have been necessary to continue bombing on the same scale for twenty years. The atomic bomb, in particular combined with a carrier such as the V-2, has changed the basis of this barbaric arithmetic. Without counting the psychological effects or the radio-active rain, some fifty H-bombs would cause the same destruction within a few minutes as would have taken twenty years of conventional bombing.

Threat to industry

It needed the advent of the hydrogen bomb to make America consider the problem of protecting its industrial potential. Writing in *U.S. News and World Report*[1] Admiral Moreell, Chairman of a group of steel companies, calculated that a single H-bomb dropped in the Pittsburgh area would destroy close on 18 % of the total American steel output, and that a second H-bomb, on the Chicago-Gary district, would raise this percentage to one third of the country's total capacity. The question is whether, in view of the destruction caused on both sides, war would continue long enough to exhaust atomic stockpiles. If an aggressor decided to gamble all on one tremendous initial blow aimed at avoiding the effects of prolonged retaliation, he would doubtless ignore all those targets which were not essential to this strategy of "immediate results", and it might be that steel mills would not figure at the head of the list of targets to be "atomized". Moreover, unless he wished to rid himself of a competitor for the future and was thus seeking to destroy his industrial potential, it is even easier to paralyze his activity temporarily. Admiral Moreell quotes the case of the bottlenecks in the Great Lakes district through which 65 % of the ore treated in the United States must pass (Sault Ste. Marie). A single 20-kiloton atomic bomb would be sufficient to destroy the locks. At the Western end of Lake Superior there is Duluth and its installations, which handle practically all the ore passing through Sault Ste. Marie. One H-bomb would wipe out the port and its docks . . . Other industrial complexes are also vulnerable to atomic bombs, in varying degrees (see map overleaf), and it is doubtful whether this state of affairs can be altered. American steel firms have studied the problem and have limited their ambition to dispersion of 25 % of their production capacity. It would cost about $10,000,000,000 to put even this project into execution. New installations from now on will probably be designed and sited to fit into a programme of progressive dispersion. But it would take *decades* for this new kind of reconversion to reach a degree of efficiency corresponding to the destructive range of *present* atomic bombs.

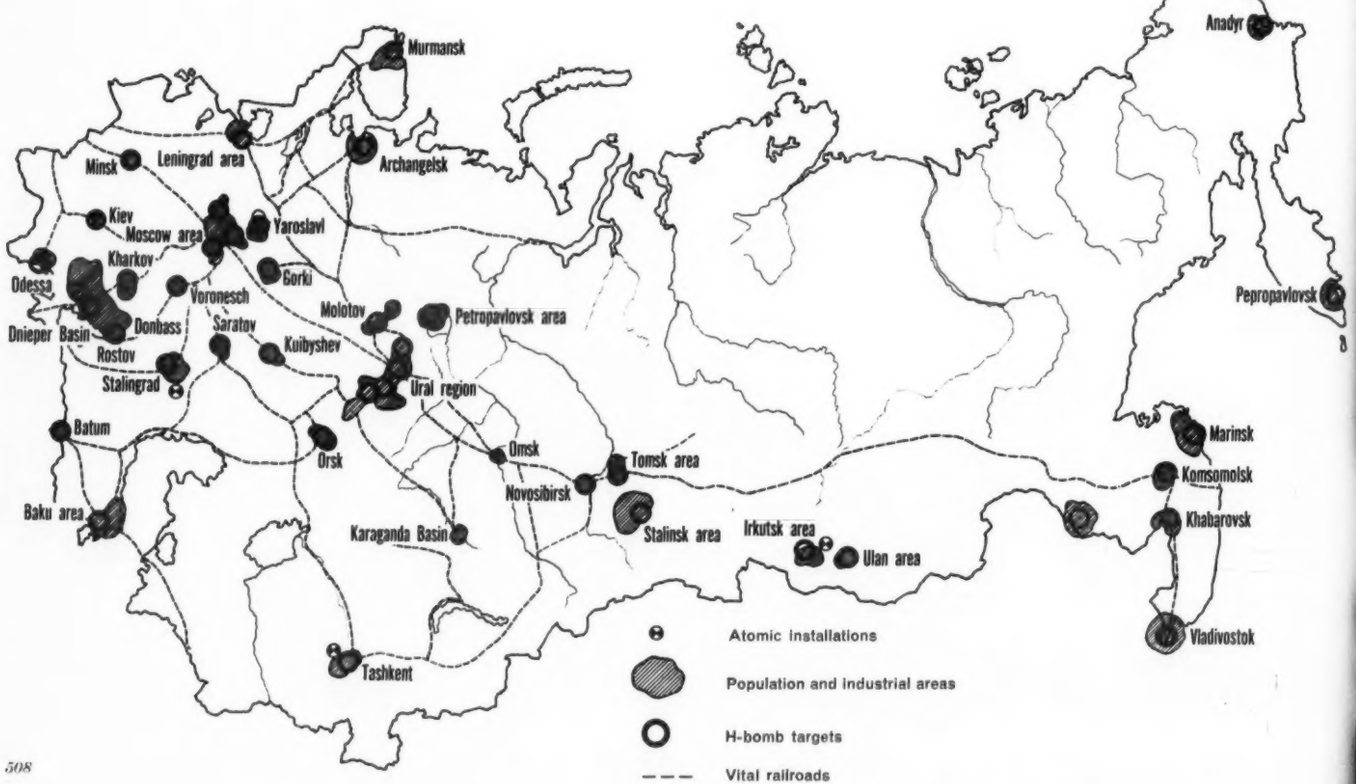
Sounding the sensitivity of a nation to the atomic disease is probably an arduous task, but the experts should have no difficulty in collecting material for their deliberations.

[1] May 7th 1954.



United Staates: Population centres, steel industry, sources of electric power, atomic production centres and special bottlenecks in the transport system (ore route) form the list of vulnerable points whose destruction would paralyse a war effort even if it did not annihilate all will to fight. Assuming that the H-bomb has a radius of destruction of 25 miles (40 kilometres), it is clear that a relatively small number of these bombs (less than 40) would suffice to cause very great damage. The industrial and population concentration in the north-east (particularly the Boston – Chicago – Washington triangle) suggests that a mass attack on this region alone would be more decisive than a dispersed attack on all the centres in the south, centre and west.

U.S.S.R.: The part of the U.S.S.R. which is most vulnerable, or rather sensitive, to the atomic weapon is still in European Russia, except of course for the centres of atomic production (Irkutsk, eastern slopes of Urals). A similar calculation to that made for the United Staates shows that less than fifty H-bombs could inflict grave damage and paralyse any sustained war effort, particularly if directed against supplies for armoured or mechanized divisions of the type known today. The position is quite different as regards lighter units which could live on their own reserves and intervene against enemy units deprived of their heavy equipment.



Without high-performance all-weather interceptors – such as the U.S.A.F.'s Northrop F-89 D *Scorpion* shown here – a breachless defence line would be unthinkable

N.A.T.O.—2

N.A.T.O.'s Aerial Punching Power

Nearly half of the air forces available to the North Atlantic Treaty Organization—estimated at 5,000 planes in all—is dedicated to the defence of Central Europe, now as always the key to successful defense against aggression from the East.

These 2,000 or more aircraft—including fighters, fighter-bombers, light bombers, reconnaissance and transport craft—are operationally controlled by *two Allied Tactical Air Forces*, each representing three of the six nations in Allied Air Forces, Central Europe (AIRCENT).

The *Second Allied Tactical Air Force* (2nd A.T.A.F.), commanded by Air Marshal Sir Harry Broadhurst, R.A.F. encompasses the British zone of Germany and the Benelux nations. It includes the N.A.T.O. air commitments of the United Kingdom, Belgium and the Netherlands.

The *Fourth Allied Tactical Air Force* (4th A.T.A.F.), headed by Major General Robert M. Lee, U.S.A.F., embraces the U.S. and French zones of Germany plus a string of American and French bases in eastern France. In addition to French and American units, 4th A.T.A.F. contains the Royal Canadian Air Force First Air Division, which has taken up positions in the French zone of Germany and to Eastern France.

Second A.T.A.F. is more highly integrated than 4th A.T.A.F., since its two tactical groups are international, while the three air formations in 4th A.T.A.F. are organically national. No. 2 Group of 2nd A.T.A.F. is made up operationally of about five R.A.F. wings and three Dutch wings. Its complementary formation, No. 83 Group, has the strength equivalent to two wings each of R.A.F. and Belgian aircraft. Hard core of 2nd A.T.A.F. is provided by the British 2nd Tactical Air Force in Germany, which maintains a complex of airdromes extending as far forward as Fassburg, less than ten minutes flying time from Russian airfields.

Unlike the U.S. Air Force in Europe, which staged a wholesale tactical withdrawal to new bases behind the Rhine to meet a possible menace from the East, the British 2nd Tactical Air Force still remains in much the same position as it was on V-E Day. To compensate, they have emphasized a high degree of mobility. Today they believe they can move several hundred miles at a few day's notice—which they would get as a prelude to any large-scale Russian build-up in East Germany and Soviet satellite countries.

Fourth A.T.A.F. today is growing rapidly. Two additional American F-86 *Sabre* fighter-bomber wings are marked for France by fall. They will join the present U.S. component of four fighter-bomber wings and two tactical reconnaissance wings. Two transport wings, while in the N.A.T.O—committed U.S. 12th Air Force's domain, recently were made a separate U.S. command under U.S.A.F.E. and no longer are counted in the U.S. contribution.

The *First Canadian Air Division* is due to receive its 4th and last fighter-bomber wing this fall. It is temporarily stationed in England, awaiting completion of its bases in France. The Canadian wings are equipped with new Canadair-made Mark V *Sabres*, considered the best fighter aircraft in squadron service around the world. It is powered by a new Avro-Canada *Orenda 10* engine providing much better climb and ceiling than the U.S. *Sabres* now in Europe.

The third component of 4th A.T.A.F. is the *French First C.A.T.A.C.* composed of 28 interceptor, fighter-bomber and reconnaissance squadrons. The French units are now receiving the Dassault *Ouragan* jet fighter, a first-class, dependable aircraft, in large numbers. Next year it is scheduled to be replaced by the Dassault *Mystère*, the first of which was turned over to the U.S. and then to the French Air Force in June under the American off-shore procurement program.

Again operationally, both A.T.A.F.s are commanded by Air Chief Marshal Sir Basil Embry, R.A.F., AIRCENT Commander, whose headquarters is located in Fontainebleau. Embry's staff is a representative one, drawn from the six nations who man the headquarters as well as provide the field forces.

Both at a headquarters level and in the field, AIRCENT works closely with the allied land forces it is pledged to support tactically as its primary mission.

In Fontainebleau, both AIRCENT and the land command—LANDCENT, headed by French Lt. Gen. Marcel Carpentier—are responsible to the overall commander for Allied Forces in Central Europe (AFCENT), Marshal of France Alphonse Juin.

In the field, the 2nd and 4th A.T.A.F.support the Northern and Central Army groups respectively. The Northern Army Group of General Sir R. N. Gale, British Army, is composed of the First Corps of the British, Belgian and Netherland armies. The Central Army Group, under General W. N. Hoge, U.S.Army, comprises the U.S. 7th Army and the French First Army.

Two other elements bear heavily in any contemplated air defence of Central Europe. They are the national air defence commands of AIRCENT's three continental powers and the so-called "Exterior Forces"—the Royal Air Force Bomber Command and the U.S. Strategic Air Command, whose mammoth jet bombers operate from the British Isles and North Africa.

In keeping with national desires, Belgium, France and the Netherlands maintain air defence commands independent of their N.A.T.O. commitments, although by nature closely related with the Allied air force in Central Europe. Exercises since the inception of AIRCENT over three years ago have repeatedly stressed close cooperation among these continental air defence commands and the two Central European A.T.A.F.s.

The exterior forces, too, figure prominently in all important AIRCENT manoeuvres, as they undoubtedly would in war. During "Exercise Coronet" last August, all three European air elements—tactical forces, air defence forces and exterior forces—were tested in unison with an eye toward improving each in its designated mission.

A fictitious war between the Northern and Central Army Groups brought the tactical air force of each into action against the other. Hundreds of sorties were flown by both sides, mostly in attacks against airdromes and in interceptions. Army participation was largely limited to paper, but some ground support missions were flown.

Exterior forces based in Britain were brought into play, making heavy strategic bombing raids on targets in The Netherlands, Belgium and North Germany. In interceptions, the Dutch and Belgian air defence units got a vigorous workout. The air defence commands of the United Kingdom and France got into the act by exchanging information on weather and radar trackings.

Should war come, such highly integrated action would become imperative, and the responsibility for its direction and coordination would fall to *General Lauris Norstad, U.S.A.F., Air Deputy to General Alfred M. Gruenther, S.H.A.P.E. commander*. Norstad knows intimately the tactical air situation in Central Europe, having commanded AIRCENT during its first two formative years.

In the meantime, AIRCENT is working toward one tactical goal: a tightly-knit but highly flexible air increment, its pilots flying freely from any allied airdrome, its ground crews servicing expertly any allied aircraft. S.H.A.P.E. strategists are counting on this flexibility, coupled with atomic weapons, to offset the shock, should it come, of the numerically superior Soviet air armada, reported to be about 10,000 aircraft.

The key to this flexibility is uniformity of operational techniques, logistics and armament.

To achieve this uniformity in operational techniques, the central N.A.T.O. air forces constantly exchange whole units: American squadrons fly for several weeks from British bases. During exercises, Canadian jets operate from American bases, British from Dutch bases, and so forth.

Uniformity of logistics and armament has been simplified by the acceptance and use of a few standard makes of aircraft—primarily the Republic F-84 *Thunderjet*, long a standby of N.A.T.O. Today it is giving way to the North American F-86 *Sabre* jet as AIRCENT's basic weapon. The *Sabre*, N.A.T.O. officials emphasize, is intended only as an interim aircraft, pending delivery of the new Republic F-84F *Thunderstreak*, a swept-wing modification of the *Thunderjet* which boasts the speed and climb of a *Sabre*-class fighter without the loss of the *Thunderjet's* tactical fire-power, range and bomb load.

The *Sabre* fighter-bomber in use today has a more powerful engine and stronger wings, with additional bomb and rocket racks, than the *Sabre* interceptor of Korea fame. In addition, it is equipped with 200-gallon external tanks for longer range.

Further uniformity has been accomplished by building up Western Europe's air facilities through a common N.A.T.O. infrastructure program. By the end of 1954, AIRCENT will count roughly 160 N.A.T.O. airfields, each with a 7,000-feet runway capable of handling jets, built from a common N.A.T.O. financial pool to common specifications.

Canadian contribution to Europe's air defences: Canadian-built North American F-86 *Sabres* of the R.C.A.F. No. 4, Fighter Wing, today stationed at Baden-Söllingen, Germany.

N. A. T. O. AIR FORCES IN EUROPE

Commands and Units	Bases	Equipment	Air Force personnel strength	Tac. Air Sqds. assigned to NATO	NATO-built airfields	Remarks
Allied Air Forces Central Europe						
Hq. 4th A.T.A.F. Maj. Gen. R. M. Lee (U.S.), Commander	Trier, Germany					
12th U.S. Air Force						
Hq. 12th U.S. Air Force	Ramstein, Germany					
86th Fighter Bomber Wing	Landstuhl, Germany	F-86F	(U.S.) 913,000	(U.S.) 34		
36th Fighter Bomber Wing	Bitberg, Germany	F-86F				
50th Fighter Bomber Wing	Hahn, Germany	F-86F				
48th Fighter Bomber Wing	Chaumont, France	F-86F				
36th Light Bomber Wing	Laon, France	B-26				
10th Tactical Recon. Wing	Spangdahlen, Germany	RF-80 & RB-26				
66th Tactical Recon. Wing	Sembach, Germany	RF-80 & RB-26				
1st Canadian Air Div.						
Hq. 1st Canadian Air Div.	Metz, France					Equipped with *Sabres* F-86E (RCAF); being re-equipped with *Sabre Mk. 5*. RCAF/Europe also have a few T-33.
No. 1 Wing (Fighter)	North Luffenham, Great Britain (to be moved to Marville, France)	F-86E F-86E	(Canada) 43,300	(Canada) 12		
No. 2 Wing (Fighter)	Grostenquin, France	F-86E				
No. 3 Wing (Fighter)	Zweibrücken, Germany	F-86-E				
No. 4 Wing (Fighter)	Baden-Söllingen, Germany					
Maintenance Base	Langar, Notts., Great Britain					
1rst C.A.TAC. (France)						Hitherto equipped with *Vampires*, the French Fighter Wings are now receiving the *Ouragan*, and the 2nd Wing is completely re-equipped. The *Ouragan* is to be supplemented next year by the *Mystère II*. The French fighter bomber wings have the standard F-84, except that the earlier machines received were the F-84E, instead of the more widely used F-84G.
Hq. 1st C.A.Tac.	Lahr, Germany		(France) 123,000	(France) 18	(France) 45	
2nd Fighter Wing	Dison, France	Ouragan				
4th Fighter Wing	Bremgarten, Germany	Vampire				
1st Fighter Bomber Wing	St-Dizier, France	F-84				
11th Fighter Bomber Wing	Luxeuil, France	F-84				
3rd Fighter Bomber Wing	Rheims, France	F-84				
9th Fighter Bomber Wing	Lahr, Germany	F-84				
33rd Tactical Recon. Wing	Cognac, France	RF-84G				
Hq. 2nd A.T.A.F. Air Marshal Sir Harry Broadhurst (U.K.) Commander	Bad Eilsen, Germany (to be moved to München-Gladbach, Germany)					The strength of the 2nd ATAF wings is rather loose but, in general, they are composed of 3 squadrons each. RAF squadron establishment is 16 aircraft, while the NATO standard is 25 aircraft per squadron. Completing the strength of 2nd ATAF are 4 wings each of Dutch and Belgian F-84. Total strength of the Dutch Air Force is 21 fighter squadrons and 400 aircraft, stationed at seven main bases. The Belgian Air Force has 400—500 aircraft.
No. 2 Group, Tactical Units (Netherlands and U.K.)	(Bases 2nd A.T.A.F.:) Buttswellerhof, Brüggen,	Venom FB-1 Vampire	(U.K.) 280,000	(U.K.) 40		
No. 83 Group, Tactical Units (U.K. and Belgium)	Ahlhorn, Geilenkirchen,	F-86E (Canadair)	(Netherlands) 18,000	(Netherlands) 14	(Netherlands) 13	
No. 69 Group, Air Defence (Netherlands and Belgium)	Wildenrath, Wahn, Gütersloh, Bückeburg,	Meteor 8 Meteor FR 9	(Belgium) 21,200	(Belgium) 17	(Belgium) 14	
Belgian Fighter Sector	all in Germany	Meteor PR 10			(Luxembourg) 1	
Netherlands Fighter Sector	(Dutch Units of No. 2 Group:) Volkel, Twente, Beek, Eindhoven, all in Holland. (No. 83 Group:) Chièvres, Beauvechaine, Florennes, all in Belgium	Mosquito Meteor NF 11				
Allied Air Forces Northern Europe **Hq. A.A.F.N.E.** Maj. Gen. W. R. Carter (U.S.), Commander 18 Squadrons (Norway and Denmark)	Oslo, Norway					AAFNE includes entire air forces of Norway and Denmark, to be made up of 18 squadrons. Norwegians are providing 10 squadrons; eight are to be formed by the end of July. Danes are providing 8 squadrons. Norwegian Air Force strength: about 200 aircraft. Seven airfields have been approved, under the infrastructure programme, for construction in Denmark. One completed at Vaerbose.
Norwegian Air Force 10 Squadrons		F-84	(Norway) 6,000	(Norway) 10	(Norway) 10	
Danish Air Force 8 Squadrons		F-84 Meteor 11	(Denmark) 6,900	(Denmark) 8	(Denmark) 7	
Allied Air Forces Southern Europe **Hq. A.A.F.S.E.**	Florence, Italy					
Subordinate Commands: **6th A.T.A.F.** Lieut. Gen. Craigie (U.S.), Commander (Italy, Greece, Turkey)	Izmir, Turkey					
Italy 6 fighter squadrons 2 recon. groups (Navy) 1 recon. wing (Army) 3 transport squadrons Liaison, rescue and training units		F-84	(Italy) 42,000	(Italy) 15	(Italy) 21	Twelve NATO airfields being built. The Royal Hellenic Air Force is receiving F-86 from Canada.
Greece Fighter, Bomber, Transport units		F-84 Helldiver	(Greece) 12,000	(Greece) 7	(Greece) 5	*Mosquitos*, *Beaufighters*, *Thunderbolts* of the Turkish Air Force are being replaced by F-84 and F-86 from Canada.
Turkey (About 95% of the Turkish armed forces are put at the disposal of NATO)		F-84	(Turkey) 29,000	(Turkey) 12	(Turkey) 9	Esenboga air base completed. Nine other air bases are being expanded.
Portugal 2 Squadrons (operational)	Ota, Lisbon	F-47 F-84 Hurricane Spitfire	(Portugal) 4,000	(Portugal)	(Portugal) 1	Portuguese *Thunderjets* have taken part in Central European air exercises with success, integrated with the French Air Force.

Infrastructure

The fourth increment of the NATO common infrastructure program brought AIRCENT to an airfield schedule of 160 under construction in six European countries. These will include aerial bombing and gunnery training bases, and anti-aircraft artillery and tank gunnery ranges. This increment also provided for the beginning of the NATO jet fuel pipeline, with its pumping stations, storage tanks, and possibilities of expansion into a greater system as demand increases.

120 airfields completed; the remaining 40 to be completed before the end of 1954.

"Failure to maintain a strategic air force in readiness is equal to inviting war." The U.S.A.F. has taken delivery of hundreds of Boeing B-47 *Stratojet* six-engined bombers, now the mainstay of S.A.C.'s medium bomber fleet. Each *Stratojet* costs nearly $3,000,000. Picture shows a B-47 E.

The U.S.A.F. Strategic Air Command

By Major General J. B. Montgomery

Commander, U.S.A.F. Eighth Air Force, Fort Worth, Texas

Why the Strategic Air Force is Needed

As a logical consequence of the evolution of both aircraft and weapons, the doctrine of strategic air power has at last achieved full recognition from the informed public of the free world, although the beginnings of strategic air operations were discernible already during World War II.

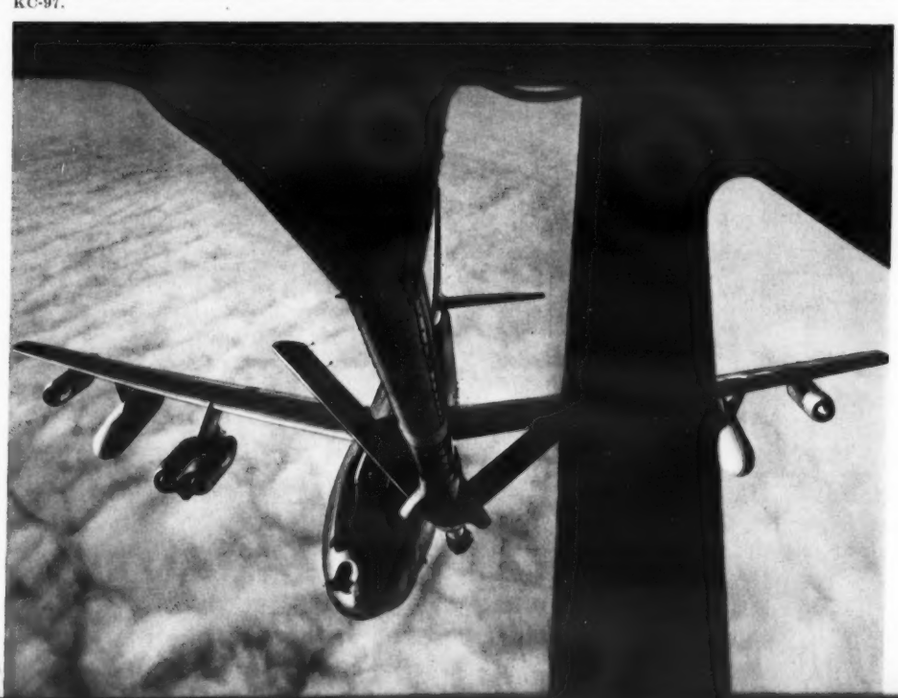
The first U.S. Bombardment Group arrived in England early in 1942, a few months after Pearl Harbor—a mere handful of men and equipment. The first United States bomber attack was flown in August, 1942, by a small force of Boeing B-17 *Flying Fortresses* attacking targets in France.

In some quarters great accomplishments were expected immediately, but naturally they were not immediately forthcoming. As the months went by, many people in the United States and Britain were sorely dismayed at the disappointing results of early bombing attacks. Some of the more impatient observers were even inclined to conclude that air power was a failure.

Had the United States possessed a bomber force at the outbreak of hostilities, and had that force been well trained and equipped—as the Strategic Air Command is today—the evolution of the war probably would have been much more rapid. Even so, it was the U.S. Army Air Forces, together with the R.A.F., which eventually destroyed the sustaining power of a powerful nation. From the beginning of 1941 through 1945 a total of approximately 2,500,000 tons of bombs was dropped by U.S. and British bomber fleets against targets in Axis countries. Each force delivered approximately one-half the total tonnage. Delivery of these bombs required 1,500,000 individual bomber trips. It cost the United States and Britain 22,000 bombers and over 158,000 combat crew personnel.

The author, Commander of S.A.C.'s Eighth Air Force at Carswell Air Force Base, Fort Worth, Texas, has long been a strategic bombing expert. Prior to assuming his present command he served as Director of Operations at S.A.C. Headquarters and previously was Executive Officer in the office of the U.S.A.'s first Secretary of the Air Force, Stuart Symington.

Range of the B-47 *Stratojet* bomber is lengthened by in-flight refuelling. The tanker here is a piston-engined Boeing KC-97.



Based on the official report of the United States Strategic Bombing Survey—a civilian commission appointed by President Truman to evaluate air attacks against Germany and Japan—the result of European operations can be generally summed up as follows:

— A general economic collapse
— 61 cities destroyed or heavily damaged
— Key industries destroyed or heavily damaged
— German air force destroyed or immobilized
— 22 per cent of all housing destroyed
— 300,000 people killed
— 780,000 people wounded
— 7,500,000 people homeless
— Overall transportation system destroyed or disrupted
— German armies isolated on the battlefield

Now I would like to call your attention to this fact: of the 2,500,000 tons dropped on Germany and her Allies, only 17 per cent were dropped during the first three years of the war. It took the United States and Great Britain that long to build up an effective bomber force.

Had our factories been under atomic attack from the outset of the war, it would have been impossible to build this force. But in a little over a year, 2,000,000 tons were delivered, and the effect was pronounced.

Now for a look at Japan:

On a smaller scale, the story of the air attack against Japan closely parallels the attack against Germany. During the 3½ years between Pearl

Standard long-range bomber of the U.S.A.F. is the ten-engined Convair B-36. It is reported to have a range of 10,000 miles.

Harbor and V-J Day, a total of 160,000 tons fell on Japan proper. Ninety-seven per cent of this tonnage was delivered by Boeing B-29 *Superfortresses* operating from the Marianas. This required 33,000 individual bomber trips over a 3,000-mile round-trip of ocean. It cost us a total of 485 B-29s and some 3,000 combat crew personnel.

Japan, a country much smaller than Germany, was more vulnerable to air attack. Although she received only six per cent of the total tonnage dropped on Germany, the results were surprisingly similar:

— A general collapse of her industries
— 66 cities destroyed or heavily damaged
— Key industries destroyed or heavily damaged
— The Japanese air force destroyed or immobilized
— 30 per cent of all housing destroyed
— Japanese armies isolated on the battlefields
— 330,000 people killed
— 476,000 people wounded
— 9,000,000 people rendered homeless
— All major ports blockaded by aerial mines, and over 1 million tons of shipping destroyed or damaged by mines dropped from B-29s.

Here again, as in the case of Germany, it required three long years for the United States to build and deploy a bomber force capable of producing decisive results.

From the foregoing, you can see why we must have a Strategic Air Command today: we cannot risk a delay of three years to build a force after war starts. Bombers can now fly across the polar regions from one continent to another. The nation with a long-range bomber force in being at the start of war can do incredible damage in a brief period and can prevent the other nation from building its striking force.

Not only that, failure to maintain a force in readiness is equal to inviting war. Those who contemplate aggression find encouragement in such neglect. Hitler relied heavily upon it. Had a powerful air striking force confronted Hitler, he might never have started World War II.

What is U.S.A.F. Strategic Air Command?

In brief terms, the mission of Strategic Air Command is to be prepared to conduct the strategic air offensive utilizing atomic weapons.

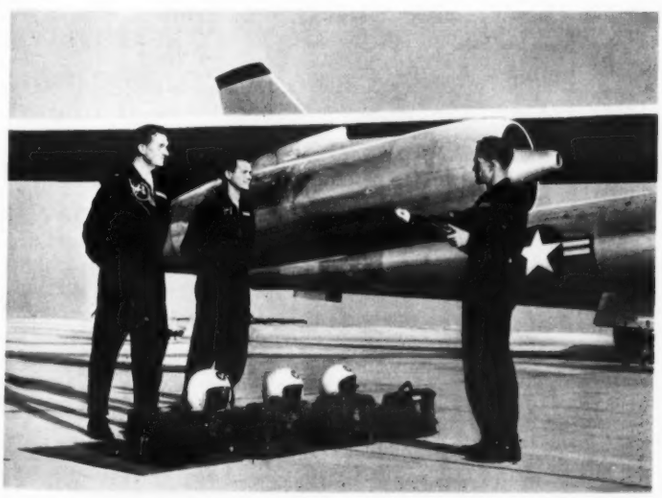
Its equipment consists of Convair B-36s, Boeing B-47s, B-50s, B-29s, Republic F-84s, tankers and reconnaissance airplanes. Other new long-range jet bombers, such as the Boeing B-52, are on order.

Commanding General of S.A.C. is General Curtis Emerson LeMay, whose headquarters are at Offutt Air Force Base, Omaha, Nebraska. There are five major subordinate units in the Command:

— The Seventh Air Division in England
— The Fifth Air Division in Morocco
— The Fifteenth Air Force, with units generally situated in the western part of the United States
— The Eighth Air Force, with units extending from El Paso, Texas, to the State of Maine, and
— The Second Air Force, with units situated generally in the eastern part of the United States.

Nine years ago, one bomb dropped from a B-29 destroyed Hiroshima. Since then, larger and more powerful atomic weapons have been developed. Any bomb, however, is effective only to the extent that it can be placed on its intended target. For this reason, our ability to penetrate, locate targets, and bomb them is a matter of

Crew of the B-47 consists of three highly trained specialists, pilot, co-pilot and bombardier, working in a pressurized compartment.



S.A.C. bases are scattered all over the world. Here the crew of a ten-engined Convair B-36 intercontinental bomber at the brand-new Limestone Air Force Base, Presque-Isle, Maine, the northernmost air base in the U.S.A., get their final pre-flight briefing prior to take-off on a training mission.

great importance. The individual crew carrying an atomic bomb becomes a very important military unit.

*

Let's take a brief look at the qualifications of the top-grade crews who man the atomic bombers of the Command.

As for the officer member of these crews, his average age is 32 years and he has been at his job for approximately 35 months.

As for the non-commissioned officer or airman member of our top combat crews, his average age is 26½ years and he has been on a crew for 29 months.

Now, for the airplane commander, the man who runs the crew: approximately 20 per cent are Lieutenant Colonels; 50 per cent are Majors; and 30 per cent are Captains; the average airplane commander is 32 years old, has 3,800 flying hours to his credit, and has 9 years commissioned service. Over half of them have had past experience in combat.

The type of experience shown here is invaluable. It is something that money alone cannot buy. It can accrue only with time and a continuing program.

*

There can be little doubt of the ability of S.A.C.'s bombers to penetrate the most elaborate air defence system it now appears possible to devise.

In this connection, even our absolescent B-29s operated successfully in Korea every day, except for 26 days, over a period of three years, against a concentration of MiG-15s that will probably never again be equalled. In the restricted area of Northern Korea the ratio of MiGs to B-29s was roughly 10 to 1. Less than one B-29 per one thousand B-29 sorties was lost to fighter action, though the MiG-15 was the Communists' latest and best fighter and the B-29 our oldest bomber.

Intelligence officers grouped around a small light looking over plans, part of the briefing of a number of crews for a 24-hour training flight. The scene is at Limestone Air Force Base, Maine.

Our present training program specializes in realistic simulated combat missions. We work closely with the Air Defense Command in testing equipment and tactics and our ability to penetrate fighter and anti-aircraft defenses. Training is pointed toward developing precision and reliability among the hundreds of crews that comprise the force and the thousands of mechanics that keep it in operating condition.

Through frequent exercises, the capability of wings and crews is put to test. For example, Omaha and many other cities throughout the U.S. have been hypothetically flattened many times by simulated drops of atomic bombs from our bombers operating day and night at great altitudes. Ground radars are positioned within Omaha to observe the approach of attacking aircraft and to measure their bombing accuracy.

Some of these bombers take off from basis in Maine, Florida, California, Arizona, New Mexico, Washington and other areas, but when they reach the bomb release line only a radio signal, rather than an A-bomb, leaves the aircraft.

Those crews failing to "bomb" or navigate within acceptable limits are given additional special training or, if inept, are reassigned to some less critical job.

S.A.C.'s Future Role

Compared with the last war, startling as were the results of bombing, the next war with atomic bombs will be entirely different. We should all attempt to reorient our thinking.

Since the atomic bomb makes it possible now to accomplish in a few days the destruction that required years during the last war, there is one important question that will probably confront this country for many years to come: "*In view of the great destructive power of atomic weapons, what is the proper size of the force to be maintained in a constant state of readiness?*"

There is, of course, no absolute answer. A balance must be struck between cost on the one hand and calculated risk on the other. The final decision must be reached with due consideration of the many military and economic factors bearing on the problem.

In this connection, I would like to leave this thought with you. *The A-bomb and its successors promise to take the profit out of war and therefore to prevent war.* With this in mind, we should approach the problem of force requirements with the question: "What size force is necessary, not only to execute the task from a purely military standpoint, but also to convince a potential enemy of the futility of starting a war in the first place?"

Only an investment of this nature will yield a useful return, since World War III, should it start, may well produce no winner but only losers, in varying degrees of destruction and bankruptcy.

*

In closing, I will summarize briefly the points covered.

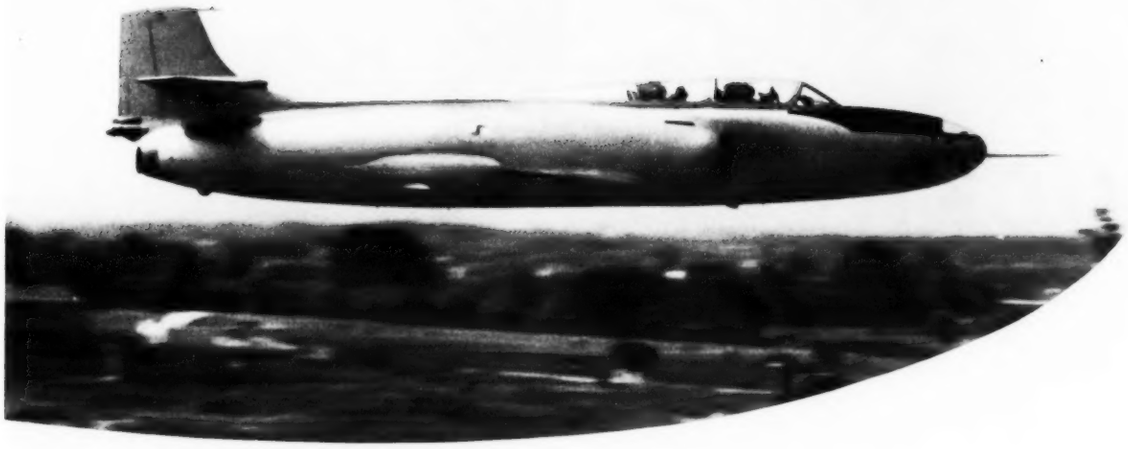
First — The United States did not have an effective Air Force at the start of the last war, and it required three long years to build one, train the people, and get into action. We will not have three years' grace next time.

Second — and most important — The atomic weapon makes it possible to bring wide-spread destruction to centers of industry and population quickly and on a scale that surpasses our imagination. *The atomic delivery force in peacetime, therefore, exerts a tremendous restraining influence on the plans and actions of would-be aggressors.* However, this power for peace cannot be effective unless we maintain at all times an adequate force to exert it—well equipped and well-manned. We should be negligent to do otherwise.

All-weather aspects of S.A.C. operations were emphasized earlier this year in "Operation North Star", a two-week training exercise which took B-36 bombers to Air Force bases in Alaska.

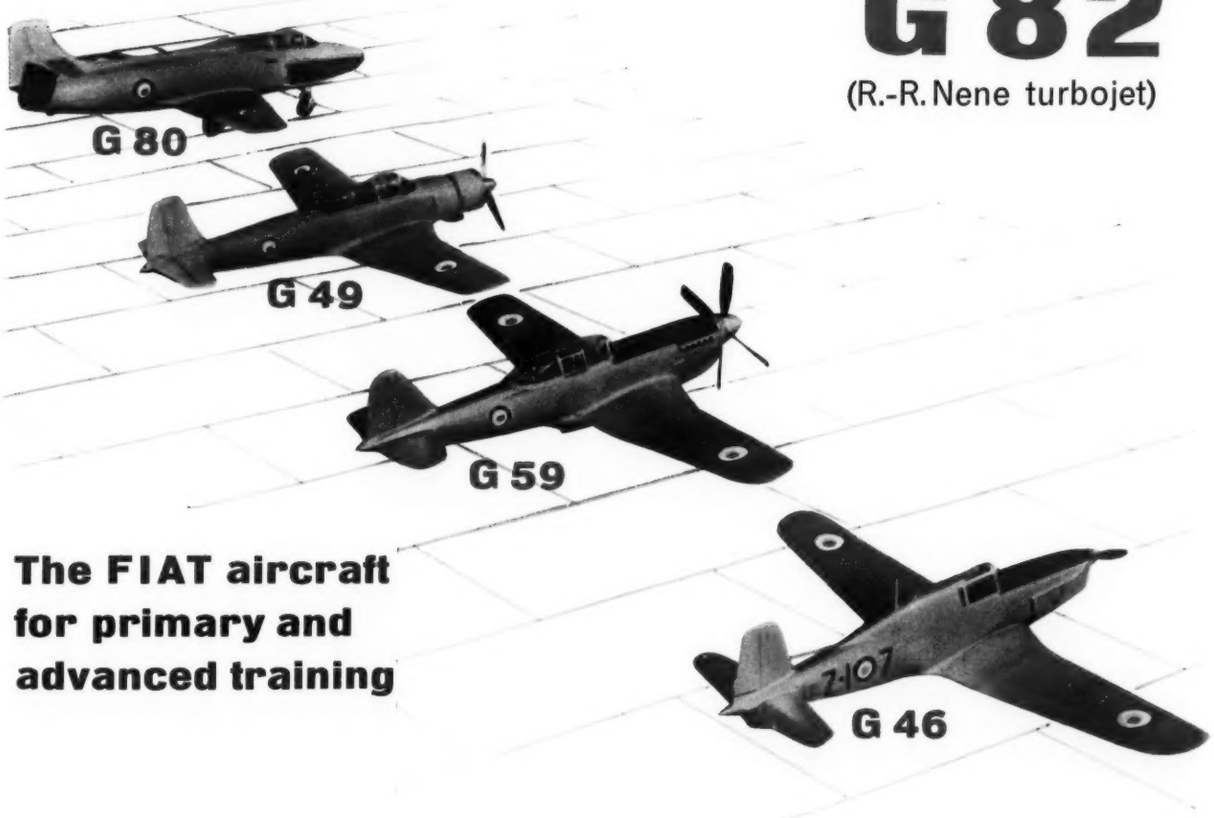
Re-equipment of S.A.C.: the U.S.A.F. has placed huge orders for the Boeing B-52 *Stratofortress* eight-engined all-jet intercontinental bomber. Prototype is seen here as it lands at Seattle, Wash.

FIAT AVIAZIONE



G 82

(R.-R. Nene turbojet)



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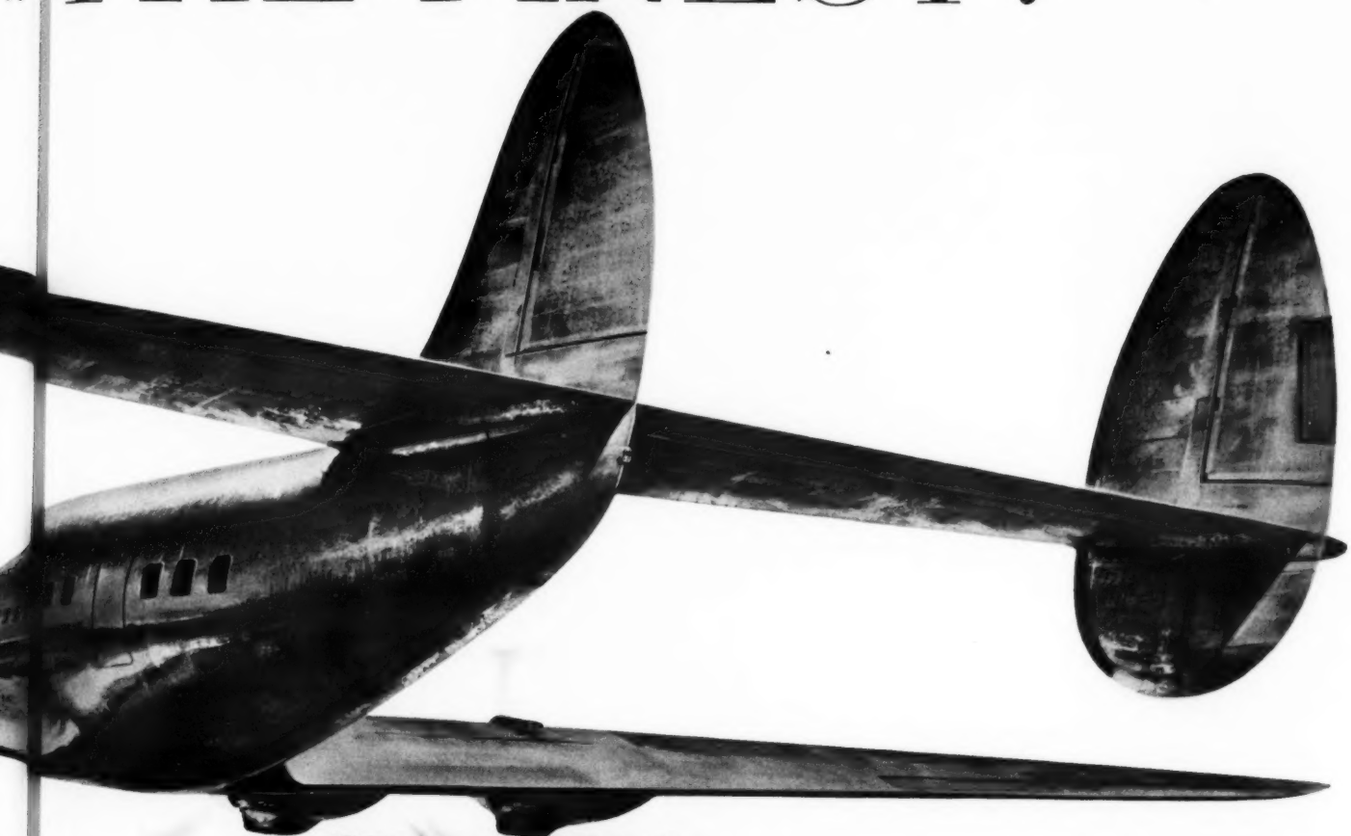

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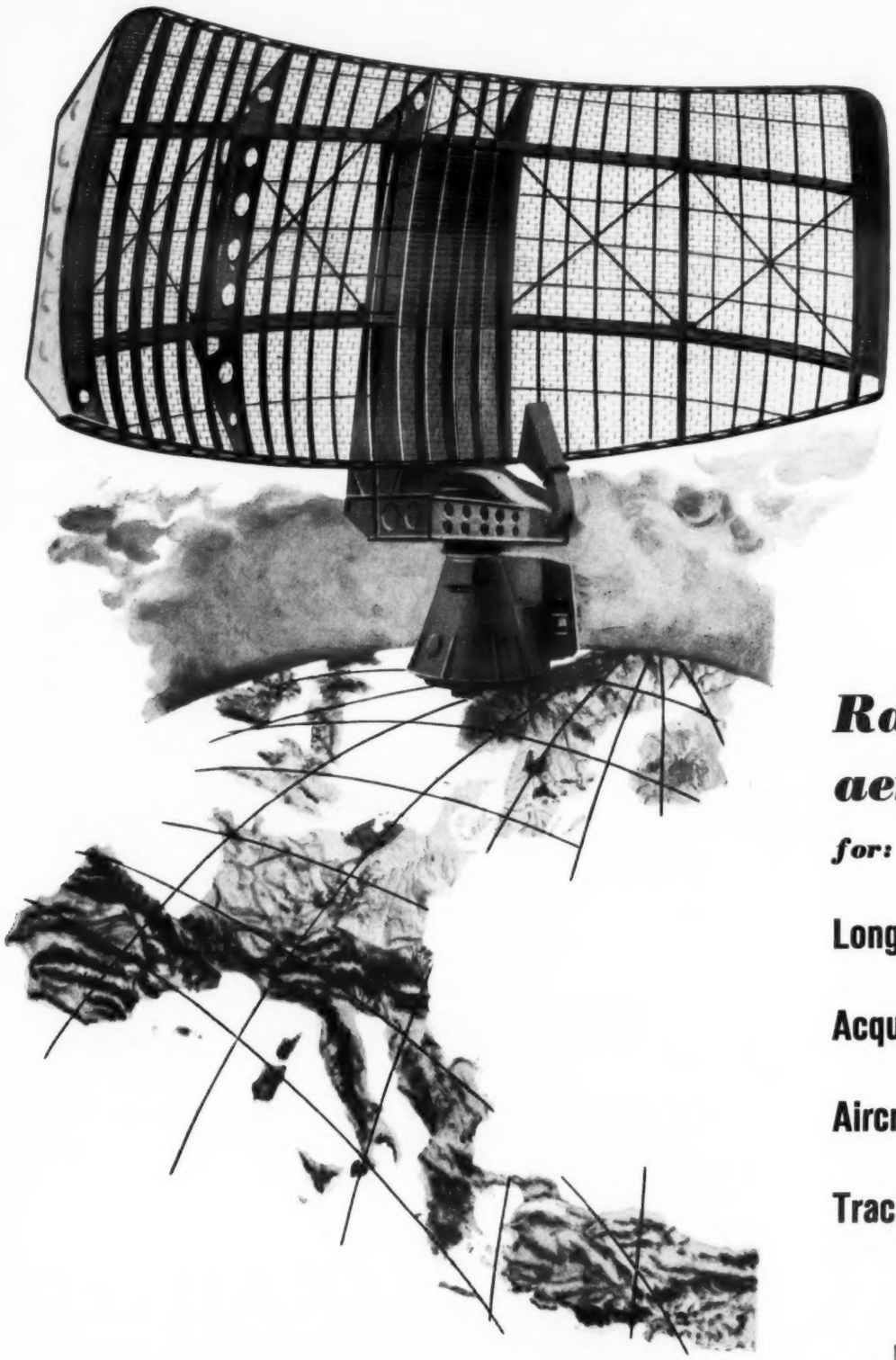

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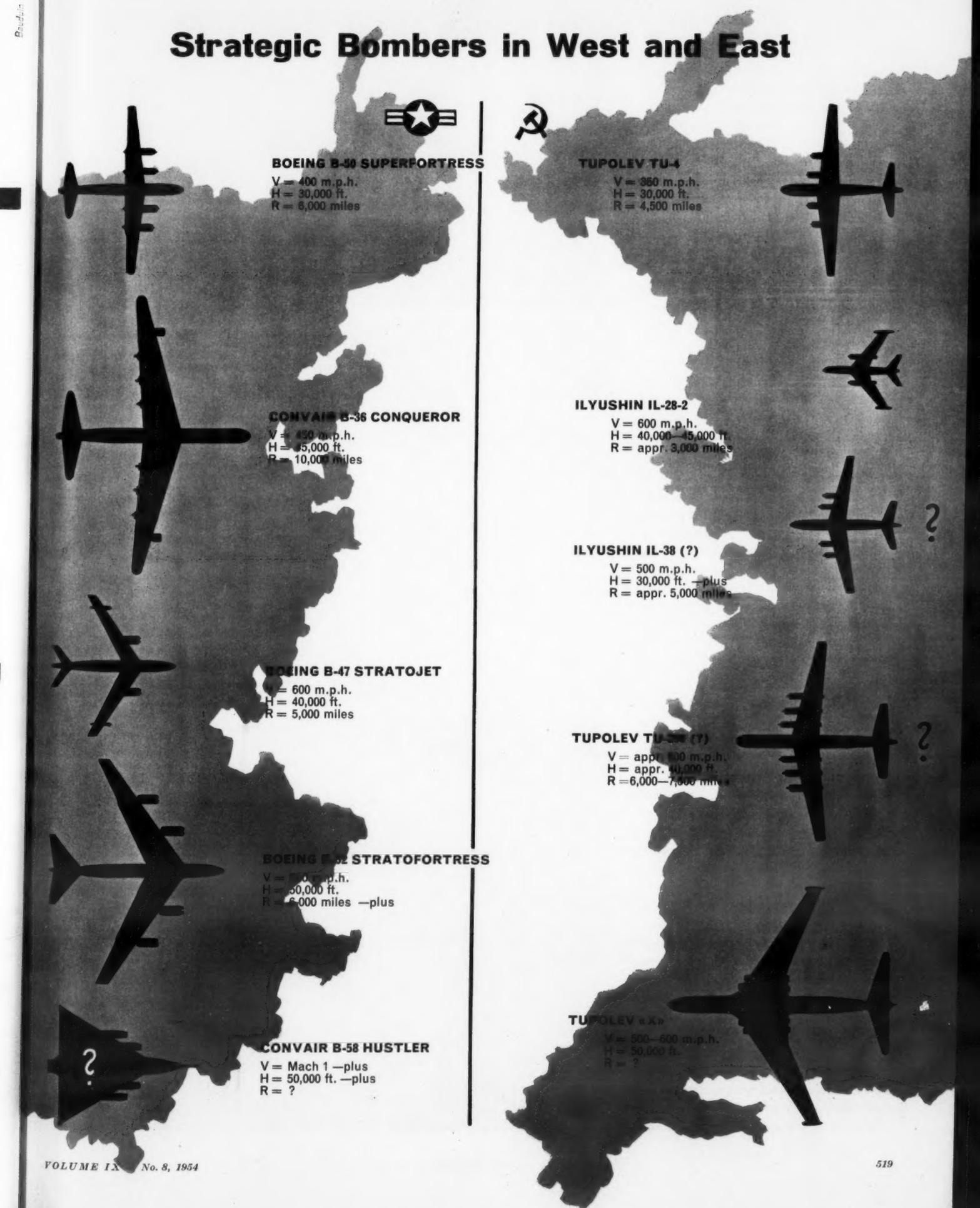


N.A.T.O.—2

Russia:
"An enigma wrapped in mystery"
(Sir Winston Churchill)

АВИАЦИЯ ДАЛЬНЕГО ДЕЙСТВИЯ

The Great Unknown. At the May Day celebrations this year a four-jet swept-wing bomber of about 185 ft. span made its maiden appearance in public. Exceptionally large nacelles are wing mounted and protrude forward and aft of the wing. The engines are reported to be in the 12,000 – 15,000 lb. thrust class. This machine is believed to be in the prototype stage only at the moment. – In all post-war Soviet air parades there has been a direct relationship between the number of aircraft in the show and actual production status. For instance, when the MiG-15 was first flown in the parade it was a prototype: next year there were 20 and the following year about 150. There has been no confirmation whatsoever of the existence of the so-called TuG-75 or Tu-200 and it certainly is not in service. All fighters have odd numbers i.e. Mig-15, Yak-15, MiG-9 etc. while bombers use even numbers. This seems to rule out the designation TuG-75.

"Aviatsiia Dalnego Deistviia" means "long-range bomber force" in Russian. But whether an effective striking force of this nature, a counterweight to the U.S.A.F.'s Strategic Air Command, actually exists, no one can tell. The experts agree that there are no experts on modern Russia. "There is no such thing as an 'old Russian hand'; there are merely those with varying degrees of unenlightenment...", said General Walter Bedell Smith, former Chief of Staff to General Eisenhower, U.S. Ambassador in Moscow, boss of the U.S. Central Intelligence Agency, now Under-Secretary of the U.S. State Department.

However, despite Soviet secrecy, despite wild post-war rumours of Soviet air strength and even wilder "technical descriptions" and "photographs" of so-called "latest" Soviet aircraft, careful observation of every sign over several years has made it possible to gather a rough picture of the Soviets' air thinking and their strength. *And one salient feature of this picture is that Russia's leadership is attaching much importance to the idea of strategic bombing in an era of atomic warfare.*

*

When the Russians overran Germany at the end of the war, they came face to face with the technical progress the Luftwaffe had achieved, particularly in the field of jet propulsion, and the terrible results obtained by British and American strategic bombing. Two immediate reactions followed: (a) they started development of a completely new range of aircraft; (b) in the light of what they had seen and the advent of the atomic bomb, they reconsidered the status of the aircraft in the Soviet military system.

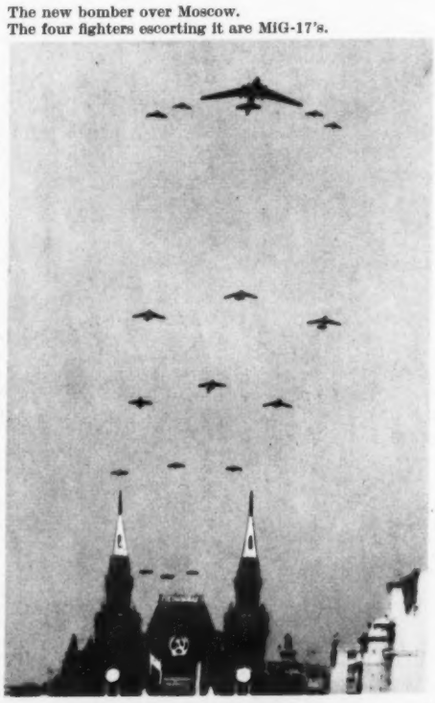
While the whole of the Soviet air fleet remains tethered to the surface forces, it appears that the Soviet long-range bomber force has nevertheless been built up to considerable strength and now more closely resembles a long-range strategic striking arm of the type exemplified by the U.S. Strategic Air Command.

According to the U.S. Author, Raymond L. Garthoff [1], Soviet air power is divided into six components, four of them under the control of the Army:

(1) *Aviatsiia Dalnego Deistviia* (ADD), the long-range strategic bomber force.
(2) *Voennye Vozdushnye Sily Sovetskoi Armii* (VVS-SA), the (tactical) Army air force:
(3) *Istrebitel'naia Aviatsiia Protivo-Vozdushnoi Oborony* (IA-PVO), the interceptor-fighter force of the air defence force.
(4) *Vozdushno-Desantnye Voiska* (VDV), the airborne troops.
(5) *VVS Voenno-Morskogo Flota* (VVS-VMF), the naval aire force.
(6) *Grazhdanskii Vozdushnyi Flot* (GVF), the civil air fleet.

[1] *"Soviet Military Doctrine,"* by Raymond L. Garthoff, of the Social Science Research Staff, The RAND Corporation, Los Angeles; prepared by The RAND Corporation for the U.S. Air Force. — Publishers, The Free Press, Glencoe, Ill.

The new bomber over Moscow.
The four fighters escorting it are MiG-17's.



Administratively, the Soviet air forces are divided into an estimated 15 to 16 *air armies* (1,000—1,400 aircraft each); an air army is subdivided into 3 to 4 *air corps*, each of 350—400 aircraft; an air corps consists of 3 to 4 *air divisions*, each with a strength of 100—150 aircraft; an air division is made up of 4 to 5 *air regiments* of 32—42 aircraft each; finally, the air regiment is divided into 3 to 4 *squadrons*, of 9—12 aircraft each. As in other air forces, the strength of the various units depends on their composition.

Total Soviet Air Force first-line strength is consistently reported as having been maintained at about 20,000 aircraft, with more than 20,000 second-line aircraft in reserve, on second-line duty, or in transport and training units. Of the 20,000 first-line aircraft, *about 1,000 are believed to be long-range bombers*, another 3,000—4,000 land-based naval aircraft (there are no Soviet aircraft carriers). Important are reports that the long-range bomber force is to be doubled.

What is known of the equipment of the Soviet air forces?

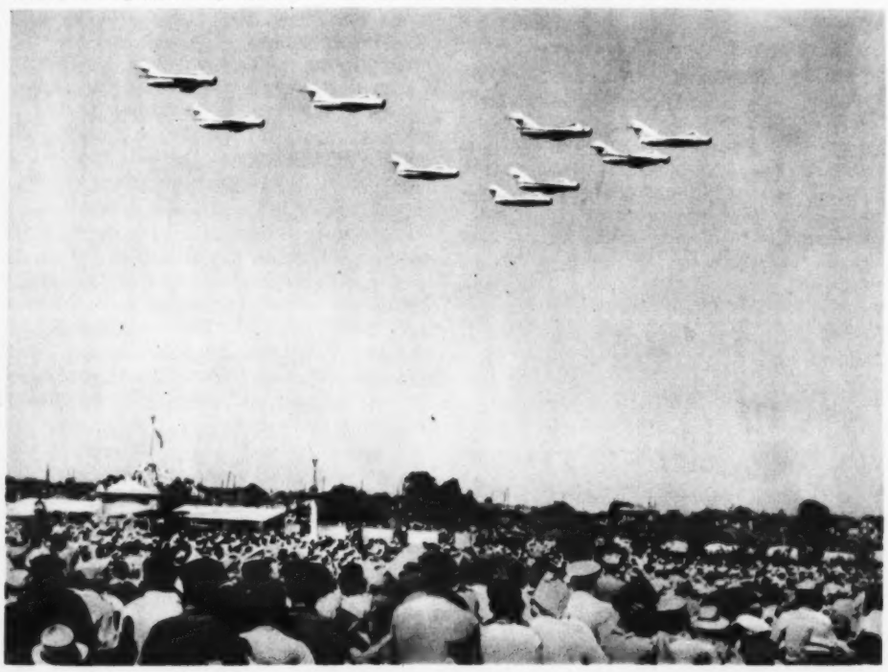
It is no secret that like other countries the Russians have made great efforts towards the complete conversion of their first-line air arm to jet operation. The first-line fighter units are already 100-percent jet-equipped, and by the end of this year also the light-bomber units are expected to be fully converted. Re-equipment of heavy bomber units may be well under way by next year. There are signs that the Russians are about to embark on a second major re-equipment programme which will last some time. This will involve chiefly light swept-wing bombers and supersonic day and all-weather fighters.

Major preoccupation of the West today is, naturally, *the A-bombing potential of the Russian strategic air arm.* In spite of sensational announcements to the contrary, the bulk of the Soviet heavy bomber forces continues to be equipped with the four-engined Tu-4 (Chinese copy of the Boeing B-29 *Superfortress)* and developments with up-rated engines (B-50 style). Other Soviet bomber types with four piston-engines, in the category of the Tu-4, have flown, but there is no indication that any have been built in large numbers.

It is quite certain that the Russians have experimented with turboprops and turbojets for bombers and have built small batches of trial airframes, more especially of medium four-jet bombers. But there is still no confirmation of the frequent reports and illustrations of a giant turboprob bomber variously called the Tu-200 or Tu G-75, which sometimes is "reliably" stated to be in existence "in large numbers". It does not seem logical that the Soviets should waste much of their time on turboprop bombers when the pure jet offers them greater simplicity and better performance. This argument is borne out by the recent publication of a photo taken at the 1954 May Day Air Parade over Moscow, which shows a swept-wing heavy bomber with four huge jets, reported to be in the 12,000—15,000-lb. s.t. class, and a span of about 185 feet.

A further Soviet Air Force development has been the adoption of helicopters for army cooperation. On Air Force Day, June 20th, thirty helicopters suspiciously resembling the Sikorsky S-55 flew over the crowds at Tushino Airport.

New version of Soviets' standard jet fighter: First seen in squadron strength at the Soviet Air Day on June 20th, a new development of the MiG-15 (MiG-17) is in full production. It apparently has an afterburner and the fin has been modified so that there is no overhang above the jet pipe. The remainder of the fuselage seems the same, but the wing seems to have greater sweep than that of the MiG-15bis. The type is expected to be supersonic.



This type *might* become the successor to the Tu-4. On the other hand, it may not. As a general rule, it seems that although the Russians may play about with all sorts of experimental types, for operational use they stick to very few well-proven types with good maintenance and overhaul characteristics.

As in other airfaring countries, bomber and fighter development in Russia has been governed to a large extent by engine availability. The first Russian jet engines were based on the early axials captured in Germany. The situation was completely changed in 1947 when the British Government of the time provided the Russians with an incredible windfall in the form of a batch of Rolly-Royce *Derwent* and *Nene* centrifugals which turned out to be excellent "prototypes" (the *Nene* went straight into the MiG-15). It is now certain that, like their colleagues in the West, Soviet engineers have more or less reached their limit with the centrifugal compressor engine with dry thrusts of about 6,500 lbs. Meanwhile, they have never ceased their work on the German engines, and new high-power axials are now believed to be in production.

*

To sum up—

There is no doubt that the bulk of Soviet military aviation remains assigned to tactical ground and naval support duties.

There is no doubt that the size of the Soviet air potential will rise slightly in future. Having almost completed jet re-equipment, having reorganized and re-equipped the satellite air forces as a "cushion" against the West and started supplying China in quantity, the Russians are bound to increase their own numerical strength.

Nor is there any doubt that since the war the Soviets have been building up a strategic A-bomber force, though its size and the performance of its equipment has often been exaggerated.

Again there is no doubt that, should Soviet military doctrine demand it, the Russians could and would create a hard-hitting high-speed jet-propelled A-bomber force comparable to that being built up in the West.

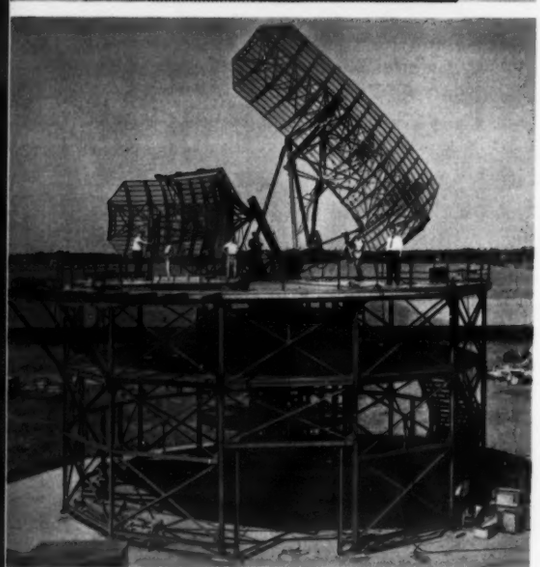
A final point: long-range guided missiles. Who can assert that the Soviets have no long-range atomic-warhead ground-to-ground guided missiles? American missiles of considerable range already exist, and the Russians have most certainly also devoted much energy to this new category of weapon. After all, they *did* get Peenemünde, a supply of German V-2s, German plans, projects and prototypes, and hundreds of German scientists after the war. However, as Churchill says, Russia is "an enigma wrapped in mystery."

Air Defence in Operation

One of the major worries of the densely populated European countries is the problem of establishing an aircraft warning system providing sufficient notice of impending air attack to enable fighter defences, anti-aircraft gun and guided missile batteries and the civil defences to go into action before the bombers can drop their loads. The same problem faces all major nations in these times of uneasy peace. The Soviet Union is reported to have just completed a chain of early warning radar stations stretching from the Black Sea to the Baltic. On the other side of the world, the U.S.A. and Canada are collaborating in the erection of powerful anti-aircraft defences along their most vulnerable border—the Arctic approaches to the industrial and population centres of the North American Continent.

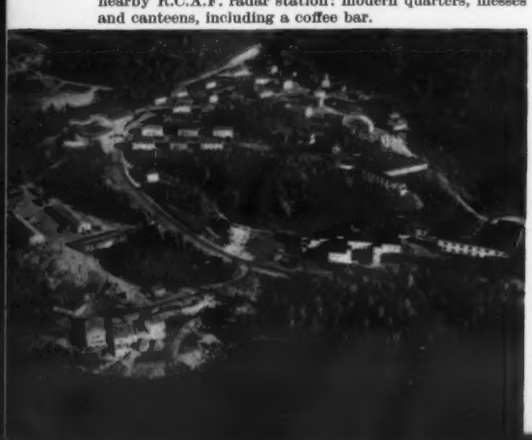
Although technical and organizational details of the U.S.-Canadian anti-aircraft defence scheme must remain secret for obvious security reasons, the scant data available nevertheless show what can be achieved by international collaboration for a common purpose.

"Scramble" at Canadian fighter base; pilots and radar operators run to their Avro-Canada CF-100 *Canuck* twin-jet all-weather single-seat fighters.



Plastic dome (top) and superstructure of a long-rang radar station in Canada's "Pinetree Chain" (made by Fleet Manufacturing Ltd., Fort Erie, Ontario, Canada).

This idyllically situated colony houses the personnel of a nearby R.C.A.F. radar station: modern quarters, messes and canteens, including a coffee bar.



In case of conflict between the two major world powers, the U.S.S.R. and the U.S.A., Canada would probably occupy the unenviable geographical position held by Belgium in the last two world wars, that of being an in-between battleground. Fortunately for Canada, the U.S.A. realizes her vulnerability from the north and in partnership with Canada is now setting up common defences in the Arctic, part of which is a vast radar warning network composed of two major chains and costing hundreds of millions of dollars.

To a great extent, Canada is depending upon what her External Affairs Minister Lester B. Pearson is credited with calling the "scorched ice defence policy." The Arctic itself, Canada believes, poses a natural barrier far more formidable than any man-made defences, simply because it is vast, empty and inhospitable. In line with this theory, Canada has been loath to establish many hard-topped landings fields with well-stocked bases in the Far North which might easily become a series of stepping stones for an invader.

The Arctic can, however, be flown over by long-range intercontinental bombers carrying atomic or hydrogen bombs, and Canada must rely upon air power to meet the threat of air power. The radar network will form the first line of defence against such surprise attacks and will, it is hoped, perform the same function Sir Robert Watson Watt's radar warning network did against the Luftwaffe during the Battle of Britain. Fittingly enough, Sir Robert was invited to Canada to aid in setting up the Canadian system.

This system consists fundamentally of an early-warning chain in the Far North, called the *McGill Fence* because McGill University, Montreal, contributed largely to the development of improved, simplified radar warning equipment requiring much less manpower for operation; and the *Pinetree Chain* farther to the south, which is already partly in operation from coast to coast.

The choosing and surveying of hundreds of possible sites for the far-North McGill Fence—over 5,000 miles long—is well advanced, and construction will begin this year. This early warning barrier is being extended by the United States across the northeastern and northwestern approaches to North America, probably to Alaska and Greenland, and is to be capable of locating low-flying as well as high-flying bombers or missiles. They are to provide six hours' warning of any attack.

The basic radar chain, *Pinetree,* is located nearer the population centres and linked to fighter aircraft control by a high frequency radio and land lines communications system.

Stations which are of primary usefulness in the defence of the U.S.A. are manned by the U.S.A.F., while installations of special usefulness to Canada are operated by the R.C.A.F. There is a provision for Canadians to take over the whole operation, if possible, later on. Canada holds title to the land on which the stations are built, and the U.S.A. owns all the equipment she has installed.

The radar systems are fully co-ordinated, and in addition Canada and the U.S.A. are working together continuously to improve the immediate defences of major target areas. Co-operation of air defence commanders is close, and unidentified aircraft are investigated by the nearest fighter interceptor force, whether Canadian or American. If U.S. planes could best fend off a potential attack on New York by meeting the enemy over Northern Quebec, they would swoop into Canada as though the border did not exist.

To set up such large radar chains the Canadian electronics industry has been built up second only to the aircraft industry in Canada's defence production programme, and so far it has cost well over $500,000,000 of Canada's defence budget. Some of this represents electronic detecting gear being installed in Canadian-produced CF-100 *Canucks* and *Sabres,* but the greater proportion is for receiving and transmission sets and various ground radar equipment. In this electronics production, as in that of aircraft, the Government policy has been to make the industry self-supporting and to reduce the number of imported items.

*

Whereas Canada's leaders do not think that a major war will break out in the near future,

Male and female R.C.A.F. radar observers at the radar screens of a ground control station "somewhere in Northern Canada".

In the radar station's plotting the positions of all identified and unidentified aircraft within the station's radius are marked on the plotting table.

Briefing before the take-off of an R.C.A.F. all-weather flight. Unidentified intruders are to be approached and, if they prove hostile, attacked.

they subscribe to the belief that "the planned build-up of strength of the free nations has been an important factor in preserving peace."

For direct anti-aircraft defence the former Canadian Defense Minister, Brooke Claxton, made plans to concentrate on ground-to-air guided rockets and guided missiles, in addition to jet fighters. He no longer believes that the anti-aircraft gun can be very effective against high-speed low-flying jets or against jet bombers at high altitude.

R.C.A.F. Air Defense Command Headquarters at St. Hubert, Montreal, headed by Air Vice-Marshal A. L. James, is in direct contact with U.S.A.F. Air Defense Command Headquarters at Colorado Springs, headed by General Benjamin W. Chidlaw, as well as with the R.C.A.F.'s air defence set-up on the West Coast, No. 12 Air Defense Group Headquarters at Vancouver, B.C. It is also in constant touch with all radar stations in the Arctic which in turn are in communication with numerous Filter Centres, the focal points of the ground observation posts. The ground observers receive special training from the R.C.A.F. and are recruited in sparsely-settled areas from fire watchers, hydro and lumbermen and above the 55th parallel from Department of Transport officials, Hudson's Bay Company factors, the Royal Canadian Mounted Police, trappers and miners. These observers attempt to plug the gaps in the radar network.

The radar site to which the Filter Centre reports is the funnel through which all information concerning aircraft flying across a wide area is channelled. It not only receives ground observer reports but may get information from an "early warning" type of radar site.

All aircraft tracks which are unknown or identified as hostile are reported to an Air Defense Control Centre, which plots the tracks received from several Direction Centres on its own display equipment.

The Commander of the Air Defense Control Centre thus is continuously informed of all aircraft flying within a huge area—including potential enemy planes. As a result, he can maintain over-all control of all the elements of air defence under his command.

On the basis of information received about unidentified aircraft, orders are given to R.C.A.F. interceptors, Army anti-aircraft units or troops. Once the interceptor has been alerted and scrambled to the attack by the ground control interceptor unit, it is directed to its target by high-frequency, two-way radio.

As it soars steeply upward for altitude, it is told the height and direction of the approaching "bandit" by the ground radar operator. He guides the interceptor by the shortest possible route until the aircraft's radar operator picks up the "bogie" on his own radar set.

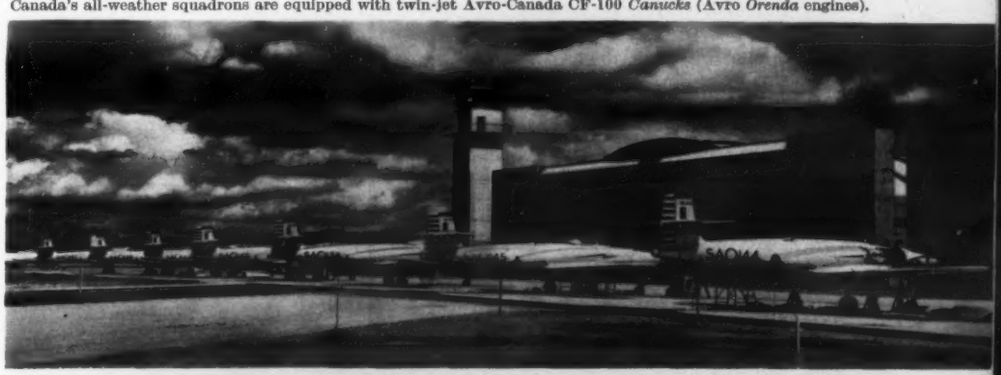
From then on the radar operator guides the pilot and plane to the point where the pilot can see the target—or if visibility is lacking, until the pilot's own scope tells him he is on target and in range. Should the unknown aircraft be hostile, they would be immediately attacked by the R.C.A.F.

The Air Defense Control Centre also furnishes air defence warning information to civilian authorities who in turn transmit it to key points at major population centres and specify the degree of warning. At "warning red," which means that an attack is imminent, air raid warnings are sounded at key points and associated subpoints, sending the populace to the air raid shelters and putting into motion the machinery of civil defence.

*

Without aircraft to intercept and destroy intruding A-bomb carriers on their way to targets in Canada or the United States, the Canadian radar chains would be of limited value. It is noteworthy that Canada, a country of less than 15,000,000 inhabitants, has built up a large aircraft industry catering to its own defence needs. By reason of the vast distances and special climatic conditions in the northern areas, the country required an all-weather long-range fighter of high rate of climb and cruising speed, with good manoeuverability and an armoury of heavy weapons. Canadian industry produced such an aircraft in the form of the Avro-Canada CF-100 *Canuck*. For shorter-range interception Canadair Ltd., are building an improved version of the North American F-86 *Sabre* fighter, which Canada has also supplied to some of her N.A.T.O. allies. For the protection of the sea approaches to Canada, the same company is making plans for the quantity production of a piston-engined anti-submarine version of the four-engined Bristol *Britannia* turboprop airliner. Avro-Canada is now working on a *Canuck* replacement, the CF-105, a twin-engined supersonic all-weather long-range delta-wing fighter designed especially for operation in the Arctic. Furthermore, Canada has developed her own air-to-air guided missile to arm her fighters.

Canada's all-weather squadrons are equipped with twin-jet Avro-Canada CF-100 *Canucks* (Avro *Orenda* engines).



The "third threat" – the submarine. At present the Soviet Union has a fleet of 350 operational submarines of more modern types than the German U-boat shown above. Even so, the German submarine menace was never beaten in the last war, and anti-submarine warfare methods have not developped sufficiently to cope with a potential underwater threat tomorrow.-Picture shows a U-boat being attacked by cannon fire in June 1942 in the Bay of Biscay after depth charges had forced it to the surface.

The third Threat —

The Submarine

by Captain Norman Macmillan, M.C., A.F.C., London

The following article by the well-known British Naval writer contains a number of unusual remarks, in particular touching on international law, on which opinions may differ. They do not necessarily represent the views of the Editors.

The N.A.T.O. coalition today faces three major threats:

(1) mass land power supported by mass tactical air power;

(2) strategic air power able to employ nuclear weapons;

(3) a concentration of naval submarine power.

The total available counter effort must be so disposed against them that there will be sufficient power to contain a thrust from (1), adequate air defence including strategic counter assault against (2), and sufficient means to check the threat from (3).

Thus the greatest strategic problem facing the N.A.T.O. States today is the correct apportionment of their total effort to meet these three basic defence requirements. As matters now stand their counter effort against (1) and (3) cannot produce a favourable military decision for the N.A.T.O. Powers, for in both they are on the defensive. The current strategic concept for the N.A.T.O. offensive therefore lies in the strategic air force.

Whether one side or the other will use nuclear weapons cannot be known beforehand (Field-Marshal Montgomery believes their use is "probable," as mentioned in the first article of this issue—Ed.), but the probability is that these weapons would be used—

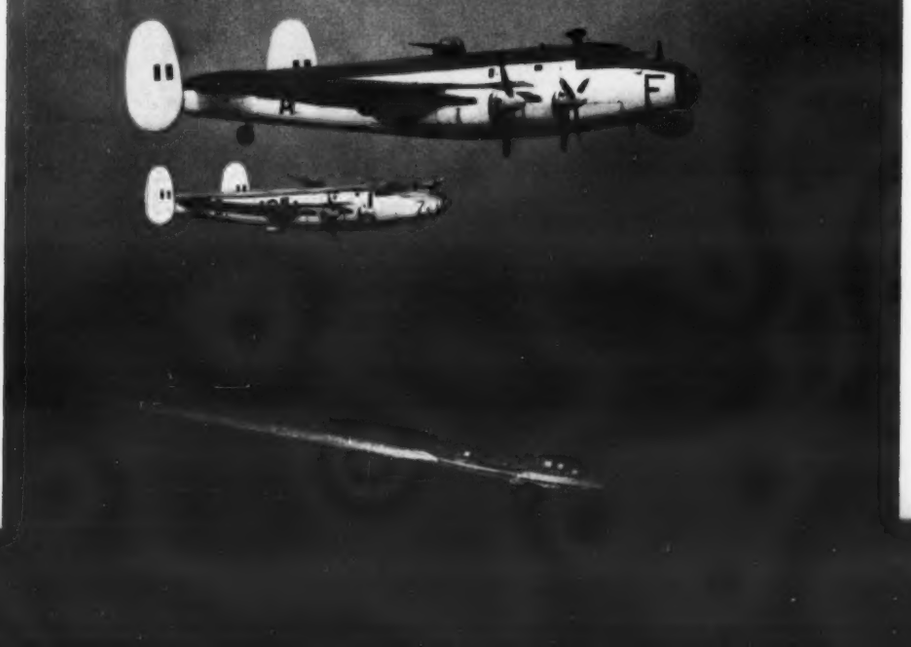
(a) in retaliation for devastating strategic air attacks with any weapons of quantitative destructive power (such as napalm bombs, for one such attack against Tokio destroyed 15.8 square miles of area against the 4.7 square miles of destruction caused by the uranium bomb dropped on Hiroshima [1]);

(b) in retaliation against unrestricted submarine warfare;

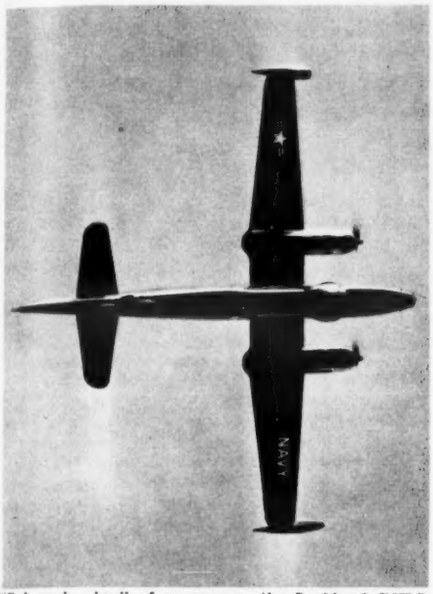
(c) to prevent excessive pressure from overwhelming land forces in a major war.

The problem we have to consider here is that of submarine warfare. From the considerations briefly outlined above, it will be apparent that the relative weight of offensive and defensive possibilities in submarine warfare will depend

Long-range, radar-equipped, heavily armed land-based ocean patrol aircraft available to N.A.T.O. today are the Lockheed P2V *Neptune*, and its British counterpart, the Avro *Shackleton*, shown here. The aircraft in foreground is a Mark 1, the one farther away from the camera a later Mark 2. – In Canada, Canadair is planning to build a piston-engined anti-sub version of the Bristol *Britannia* four-engined turboprop transport.



[1] *Editor's Note:* Here it should be remembered that napalm had its devastating effect in Tokyo because of the flimsy wooden structures making up a very large part of the city. Similar destruction would not be caused by a napalm attack on a European or American town. Furthermore, loss of life no doubt was greater as a result of the Hiroshima bomb than the Tokyo incendiary attack. Incidentally, semi-official U.S. sources now claim that the A-bombs dropped on Hiroshima and Nagasaki caused three to four times as many deaths as were announced publicly. The published death toll for Nagasaki alone was 80,000, and the new estimates would raise the actual figure to as many as 320,000 deaths.



"Sub-eye's view" of an enemy—the Lockheed P2V-7 *Neptune*. Plastic bulges are fitted with radar to track submarines.

An earlier version of the *Neptune*, in service with the R.A.F., receives its complement of under-wing rockets.

upon the relative pressure of other arms to secure their share of available resources.

Currently, the problem of the submarine is closely associated with the territorial defence of Western Europe. If the N.A.T.O. armies can hold a major attack along the present lines, the outlets for submarines into Western European coastal waters and the North, Central and South Atlantic are geographically restricted. If, before a conflict began, a large number of submarines passed from the Baltic to the open sea, they could execute considerable damage immediately war began. But the duration of their operations would be limited by their self-contained resources, plus those obtainable from supply ships organized for them in advance. In this case the policy of N.A.T.O. anti-submarine strategy would be to prevent the return of those submarines to their bases, while simultaneously stopping other forces from emerging.

In past wars it has been relatively easy for aggressive powers to pre-plan their submarine offensive, and so have a selected number of such ships at sea at strategic points ready to receive a signal to begin their lethal operations. That is definitely an unfriendly, even a warlike act. Hitherto it has been impossible for defensive powers to take any adequate measures to prevent such forces from being pre-stationed athwart their sea lines of communication. To a great extent this restriction has been imposed chiefly by regard for the rights of neutral States. But with the N.A.T.O. Powers the obstacle of neutrality has been almost abolished, and in view of the possibility that in the future such submarines might be armed with nuclear weapons (e.g. guided missiles) capable of sealing off towns and harbours, no defensive power should now neglect precautionary counter-measures in advance of war to secure its safety.

What counter-measures could be taken? Channels could be secretly mined, but that might be regarded as an act of war, and so precipitate hostilities to the disadvantage of a defensive power. The real solution of this problem—on paper—is for the N.A.T.O. Powers to declare in advance that unrestricted submarine warfare will be regarded by their combined Governments as an act of piracy, not as a legal act of war, and that they will reserve the right to use any weapon against submarines so employed.

It is improbable that any such declaration would have real effect in preventing the unrestricted use of submarines against sea lines of communication. But after such a declaration the N.A.T.O. Powers could then mine certain waters, leaving only narrow channels open for the free passage of surface vessels. And they could inform all powers through diplomatic representatives that no submarine would be permitted to pass through such channels whether on the surface or submerged without right of search. With the interlinking of sonobuoys, patrol aircraft, antisubmarine frigates, and in narrow waters shore-based radar it should be possible to provide a sufficient screen to detect the attempted passage of any submarine surfaced or schnorkelling by day or night, and so permit counter-action to be taken against it.

The strategic necessity is to force the opposing submarines to herd in narrow waters in or near to their own territory where they can be attacked by concentrated forces. Once they have become dispersed the problems of search are magnified enormously, so that the total force required to oppose them must be greatly enlarged to cover the oceans.

It should be possible to put a stopper at the mouth of the bottle of the Baltic, sufficiently in advance of any major war, to prevent the passage of submarines into the open sea. It should be possible similarly to prevent the passage of submarines through the Dardanelles. Thus, the Mediterranean and the North Sea should be free from submarine activity at the outbreak of war.

To maintain this freedom after war began would demand the employment of photographic-reconnaissance aircraft over the Baltic and Black Seas, and attack by air against all submarines and their bases within both seas. Further, it would be the duty of the land forces to prevent the advance of opposing armies in actions designed to open up other ports for the operations of submarines. And it would be essential to provide continuous fighter air cover over the bottlenecks for anti-submarine search, mining, and attack air and naval craft and their installations such as sonobuoys and radar. A major air battle would therefore be likely to be fought over the bottleneck zones.

With fully organised N.A.T.O. stopper operations for the Baltic and Black Seas, Red army strategy would perforce be deflected from some other operations into that of opening up the bottlenecks. The areas around both would become centres of bitter fighting by land/air armies. But so long as the N.A.T.O. land forces can hold the opposing land forces, the Red submarine menace can be garrotted, except from their bases at Murmansk and in the White Sea, in North Russia.

These bases present a different problem, and one of considerable difficulty. With Russia's modernised canal system it is possible for submarines to sail under their own power from strategically well-sited assembly bases for prefabricated units, either to the Baltic or the White Sea, and to transfer from one zone to

Loading depth charges on an R.A.F. *Neptune*.

Fairey *Gannet* is a ship or land-based turboprop anti-sub aircraft carrying full radar, sonobuoy and depth charge equipment.

The Short *Seamew* ist the "little brother" of the *Gannet* and in naval aircraft design pioneers the modern trend towards the rugged stripped to essentials and quickly produced.

the other. Although it is certain that the scale of operations would diminish from the northern bases in winter, this zone would have the advantage of long nights to give cover to operations and the preparation of military works.

The canal system interlinking the Baltic and White Seas would therefore become a target for strategic attack, as would the railway system running north to Murmansk and Archangelsk, and these attacks would have to be maintained to ensure the cutting of supplies from the industrial zones. Indeed, the best defence against submarines operating from the northern Russian bases might well be found in these indirect forms of attack.

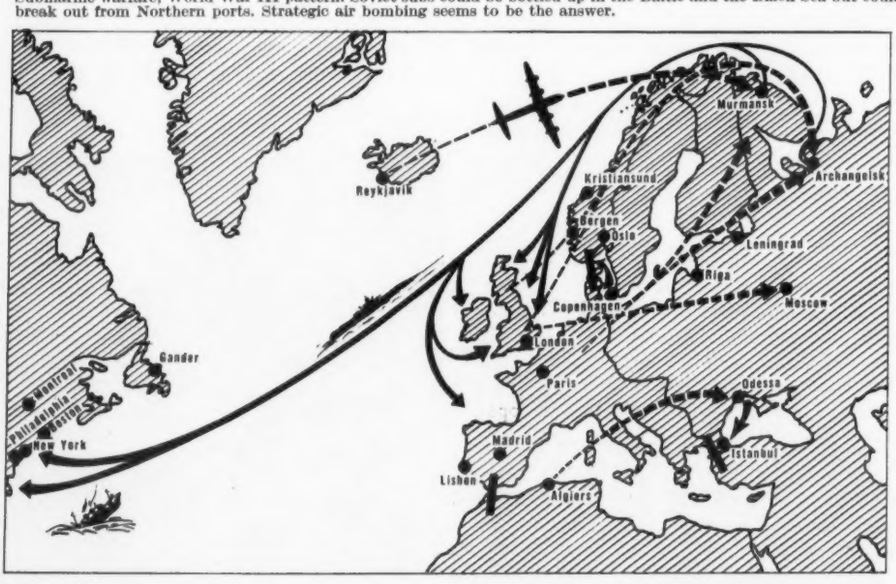
Modern jet bombers carrying conventional or nuclear weapons could operate against submarine bases located in the Murmansk-White Sea areas from Northern Scotland, Western Germany, or Denmark. No doubt they could also be used to sow mines, using special dropping gear to offset their high cruising speed.

There appears to be little possibility of occupying any of the northern Russian bases by land forces. It would be feasible, on the other hand, to land commando forces from aircraft to undertake special operations against communications and military supplies.

The recent speech made at Buckingham Palace by the King of Sweden was plain: Sweden will fight if attacked. If, therefore, the Red Army were to assault Sweden to endeavour to open up the bottleneck which can be created

Douglas *Skyraider* early warning and submarine search aircraft supplied to the British Royal Navy under the U.S. military aid programme.

Submarine warfare, World War III pattern. Soviet subs could be bottled up in the Baltic and the Black Sea but could break out from Northern ports. Strategic air bombing seems to be the answer.



strategic bombing raids

submarine routes

bottleneck "stopgers" in the Baltic, Dardanelles, at Gibraltar

These tables show the fluctuations of the submarine battle during World War II, as new equipment gave one side or the other temporary superiority. N.A.T.O. nations should realise that in any future war there will be no time to improvise and try out new methods—countermeasures must be effective from the outset.

German U-Boat Strength in World War II

Date	Operational	Training and Trials	Total
September, 1939	49	8	57
April, 1940	46	6	52
October, 1940	27	37	64
July, 1941	65	93	158
July, 1942	140	191	331
January, 1943	212	181	393
April, 1943	240	185	425
July, 1943	207	208	415
January, 1944	168	268	436
April, 1944	166	278	444
October, 1944	141	260	401
January, 1945	144	281	425

Axis submarines sunk between September 3rd 1939 and May 5th, 1945.

By	U.S. Forces and other Allied	British Empire Forces	Totals
Ships	31	205	236
Shore-based aircraft	45	180	225
Carrier-borne aircraft	32	18	50
Joint ship and shore-based aircraft	8	21	29
Joint ship and carrier-borne aircraft	6	4	10
Submarines	1	25	26
Bombing raids on U-boats afloat in enemy ports	29	8	37
	151	462	613

Sinkings of merchant vessels (gross tonnage), British, Allied and Neutral, by U-Boats during World War II

1939 (Sept—Dec)	421 000 tons	103 vessels
1940	2,125,000 »	440 »
1941	2,162,000 »	429 »
1942	6,250,000 »	1,155 »
1943	2,579,000 »	462 »
1944	733,000 »	132 »
1945 (Jan—May)	263,000 »	54 »
World War II total	14,573,000 tons	2,775 vessels

This figure of 14,573,000 is out of a total loss from all causes of 21,194,000 tons and 4,786 vessels during the war, including mines, aircraft, surface craft and other causes.

Aircraft Against Submarine

The main problem facing the aircraft combating the submarine—in spite of all kinds of new equipment and devices—still remains that of **finding** the submarine in the heaving wastes of ocean water.

Two standard types of search equipment, apart from the searchlight, are used by aircraft at present: the sonobuoy or Asdic device, and air-to-surface homing radar. Unfortunately both have to be used together as radar waves will not penetrate water to any useful extent and sound waves through water are lost in the air.

Radar serves to keep submarines under the water and thus reduces their mobility and speed. However, it is exceptionally difficult to pick up a small schnorkel tube in a vast ocean, particularly when highly sensitive radar screens become cluttered with sea returns. Only in heavy seas will a submarine find it difficult to use its schnorkel and have to surface to charge its batteries.

The sonobuoy dropped by aircraft consists of a hydrophone which sinks below the surface and an antenna attached to a buoy which is above the water and transmits. The hydrophone detects underwater noise (according to American reports British sonobuoys also give a bearing) and the transmitter relays it to the aircraft. By the use of several a reasonably accurate "fix" can be obtained and an attack made accordingly. Unfortunately the great space of the sea means that sonobuoys can only be used where there is real evidence of a submerged submarine, i.e. near a convoy or after radar or visual sighting.

The submarine now has most of the advantages, and some new method of detection is urgently needed. One new system works on the theory that any object emits waves according to its mass. If a detector can be devised for these waves, many problems in air and water detection will immediately be solved. Much private research has gone into this idea in the United States, and the U.S. Navy is known to have been interested as far back as the early 1930s.

The advent of the fast, continuously submerged atomic-powered submarine and the perfection of atomic weapons will increase the underwater threat to N.A.T.O. in the years to come. Yet, Allied naval experts believe that for at least another three or four years the bulk of Soviet submarines will consist of conventional Diesel-powered schnorkel-equipped types. Quantity production of atomic-powered submarines of the U.S. **Nautilus** category is still years away.

in the waterways between Denmark, Sweden and Norway, it would immediately become possible to increase resistance against the submarine there. But while Sweden remains outside N.A.T.O., the latter is faced with the objections of a neutral Power to military action in the vicinity of its shores which would interfere with the free passage of its own surface ships.

There is the possibility of a Red Army drive south through Bulgaria into Turkey and Greece to open up a way into the Mediterranean. And there is no great depth of defence to allow for any easing back of forces against such a drive. The possibility must therefore be faced that through the intervention of the Red Army, Red submarines might break the bottleneck and pass out through the Aegean Sea.

Thus, in addition to the threat from the northern bases which cannot be sealed off, there is the danger of the stoppering of the Baltic and Black Sea exits failing, through the inability of the land forces to retain their present positions. In this case, as in the last war, the submarine threat would become ocean-wide, and would require the deployment of large defence forces.

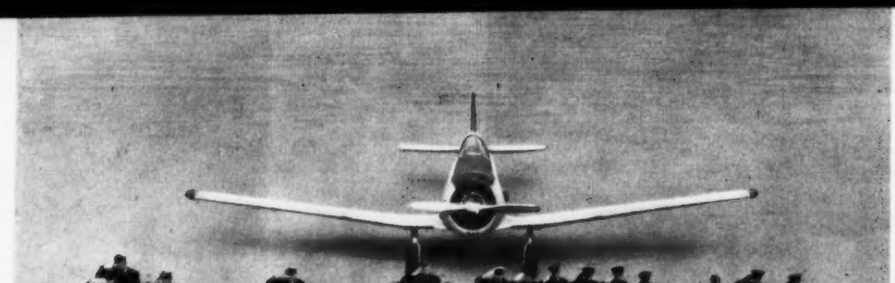
Of the 350 submarines now understood to be available to the Russian Navy, about half are of the coastal class for operation in coastal waters. The other half, however, are of medium and long-size ocean-going types capable of exerting a real atomic menace against harbours, towns and industries situated in proximity of the sea shores. (In this connection it is of interest to note that Germany started World War II with only 49 operational U-boats.-Ed.-) The smaller ships would be employed chiefly in the waters about the British Isles. Equipped with schnorkel as they are, it would be no easy task to counter their activities. To contain them, a considerable number of squadrons of special anti-submarine aircraft and anti-submarine helicopters would have to be disposed about the coastal sectors of Great Britain and Northern Ireland. Other N.A.T.O. anti-submarine forces would have to be similarly deployed from bases in north-west France, Belgium, Holland, north-west Germany and Denmark.

The R.A.F. Coastal Command force alone which faced the submarine threat in the spring of 1943, when it loomed as black as at any time in the late war, contained 16 medium and light anti-submarine and reconnaissance squadrons, 14½ flying boat squadrons, 12 heavy bomber squadrons, 7 fighter, 2 Fleet Air Arm, 8 P.R., 3 Air Sea Rescue, and 3 meteorological squadrons. It is certain that nothing like this force exists today to cover the anti-submarine requirements of N.A.T.O. Yet in 1943 the schnorkel was not yet in use, and the R.A.F. had just become equipped with centimetric radar which defeated the German submarine radar warning sets. The conditions were then far more favourable for the counter submarine forces than they are today.

The situation vis-à-vis the long-range submarine is equally unsatisfactory. Farcical as it is, it is nevertheless true that the N.A.T.O. Powers are today no better equipped with very long range aircraft to cover the mid-ocean gap than they were in the war that ended nine years ago. Lack of definite equipment for this purpose could be taken as a pointer to N.A.T.O. belief that the Red submarine threat can be contained within narrow waters, owing to the situation of the Red submarine bases. But a breakthrough by the Red Army would alter this position overnight, and instantly there would be a demand for VLR aircraft to cover the mid-ocean gap. The answer can be made available with existing aircraft by means of flight refuelling, and it is difficult to understand why Coastal aircraft have not been equipped to take advantage of this means of converting them to VLR capacity.

Thus, although the Red submarine fleet is today much stronger numerically than the largest operational German submarine fleet in the last war, the defences arrayed against the submarine have been allowed to fall, in order to provide for the land defences. It is by the ability of these land defences to hold the Red Army that the possibilities of the present N.A.T.O. anti-submarine forces must be measured. Even then they may be all too small to counter the modern submarine, which poses problems that were not solved when met at the very close of the Second World War. It is an uneasy situation which here faces the N.A.T.O. chiefs.

Helicopters are assuming increasing importance in anti-submarine warfare, because they have such invaluable features as slow speed over convoys, ability to hover and listen to suspended sonobuoys, ability to alight on merchant ships. However, their duration and load capacity are still limited, speed to overhaul a crash-diving submarine is doubtful, first cost and maintenance cost are high, and self-defence is questionable. – Progress made in anti-sub helicopter design is illustrated by the Sikorsky XHSS-1 (or S-58) at left, the Bell USL-1 at right.



. . . Air Training Centre

N.A.T.O.—2

Some 3,000 aircrew of nine N.A.T.O. nations across the European Continent, wearing the specially designed wings they won by completing their air training with the Royal Canadian Air Force, are now flying military aircraft—Canadian style.

The original Canadian offer of 1949 to train army officers and aircrew from Belgium, France, Italy, the Netherlands and the United Kingdom has since been expanded to include trainees from Portugal, Denmark and Turkey. More than 1000 pilots and about twice as many navigators have already received their wings at flying schools across Canada and another 1,000 are now in various phases of training.

Just as the British Commonwealth Air Training Plan was probably the greatest contribution Canada made to the success of the Allies against the Axis during the last war, the present R.C.A.F. training offered to aircrew of N.A.T.O. nations is one of Canada's major contributions to the N.A.T.O. preparedness program.

In line with general N.A.T.O. policy, Canada is concentrating on quality rather than quantity in her N.A.T.O. trainees. The offer made in 1949 by Canada was to train some 1,400 N.A.T.O. aircrew a year alongside 1,600 Canadians. Canada is providing, in addition to the direct cost of training pilots at $90,000 and navigators at $75,000 each, all food, accommodation, transportation in Canada, hospital and dental care.

Capitalizing on her experience with the B.C.A.T.P. under which 131,000 aircrew were turned out, including air crews from Australia, New Zealand and Britain, Canada has set up a splendid organization and excellent facilities for this training.

N.A.T.O. and general R.C.A.F. training in Canada is administered by R.C.A.F. Training Command whose headquarters is at Trenton, Ontario, under Air Vice-Marshal John Gordon Kerr. To accommodate the N.A.T.O. training build-up and to meet Canada's own training requirements, the R.C.A.F. has reopened a number of wartime training stations and accelerated its entire flying training program.

Since the first N.A.T.O. trainee graduation in July of 1950, N.A.T.O. trainees have been going through the regular R.C.A.F. training courses, the only difference in their instruction being their pre-flight three week orientation course at London, Ontario. Here they receive special language instruction, lessons in Canadian geography and customs and other information designed to ease their introduction to R.C.A.F. training techniques.

The N.A.T.O. trainees are the pick of the various national air forces and will undoubtedly be among the leaders in these units as they continue their flying careers. The Royal Air Force trainees from Britain have completed cadet training and have had considerable ground instruction before arriving in Canada. They have had two or three weeks in a manning pool and also the full Initial Training School course. All the R.A.F. trainees are at least Acting Pilot Officers (read: Lieutenants) and a few of them have enlisted in the permanent force and have outright commissions. The rank of the Continental trainees in the services of their own nations varies from AC2 (or Private) to Pilot Officer (or Lieutenant).

Some Continental trainees have had no flying training, whereas others have had combat flying

Before they start their training, N.A.T.O. students are taken on a tour of the station. Cadets here include members of the French Air Force and naval air arm and of the Danish Air Force. The party is led by the R.C.A.F. Flying Officer (i.e., First Lieutenant) in centre.

A R.C.A.F. instructor points out landmarks to two N.A.T.O. student pilots at the Centralia flying school in Ontario.

experience, mostly in the French Air Force in Indo-China. Most of these French trainees hold "Aspirant" rank.

Although the normal orientation course of three weeks consists of only 120 formal working hours, 30 of which are needed for drill and sports, experience has proved that N.A.T.O. trainees during this period make fast friends with their allies. It is felt that this friendship will contribute later to mutual respect, co-operation and friendship in the countries themselves. The trainees will return to their native countries not only with a better understanding of Canada and Canadians but of other N.A.T.O. countries with whose airmen they are studying side by side.

Language training is accomplished by direct association, not by text book or dictionary. Items of R.C.A.F. mechanical equipment are used as subjects for conversation with the knowledge that they will be of interest to the mechanically minded cadets. During certain types of off-duty breaks—such as canteen breaks—the use of English is compulsory. The orientation lectures themselves serve as language training classes and such teaching aids as phonograph records are extensively used.

A quick survey of Canadian history, geography, civics and culture is given. Discussion groups develop subjects in which the cadets want new or further information. These subjects can range from changes in the Commonwealth to the background of N.A.T.O. In addition, instruction is given in R.C.A.F. organization, history, customs and regulations. There are lectures on the relationship between Canadian civil and criminal law and Air Force law; air crew training facilities in Canada; and mess regulations and customs in Canada and in each of the other N.A.T.O. countries.

After orientation training, the cadets move on to Centralia, Ontario; Claresholm, Alberta; Penhold, Alberta and Moose Jaw, Saskatchewan, for pilot training, or to Winnipeg for navigation instruction. Their training is thoroughly integrated into the R.C.A.F. training for junior officers.

Initial flying training for pilots is carried out on North American *Harvard* basic trainers; average time taken to solo is about 25 hours. Some 200 hours are spent in the air at the initial flying school, with considerable time being devoted to such ground school subjects as theory of flight, aero-engines, navigation, meteorology, flight instruments, armament, aviation medicine, air regulations, aircraft engineering and development and radio procedures, including Morse.

Advanced flying schools are maintained at Gimli, Manitoba, Portage la Prairie, Manitoba, and Saskatoon, Saskatchewan, and a Pilots Weapons School is located at MacDonald, Manitoba. Here the more modern Canadair-produced Lockheed T-33 *Silver Star* jet trainer and the North American B-25 *Mitchell* twin-engine light bomber are used for advanced flying training. Those students training to be fighter pilots go to the T-33 jet schools while those destined for transport or maritime operations receive their advanced training on *Mitchells*.

The basic navigational training consists of three distinct phases—ground school, air training and officer development training. In ground school, staffed mainly by veteran navigators, 12 distinct subjects are covered, greatest emphasis being placed on Dead Reckoning Navigation, Methods of Long Range Navigation and their application to various navigational techniques as well as the use and manipulation of plotting and calculating instruments. Students are taught all phases of map reading and the elementary principles of map construction, and considerable instruction is given in meteorology. Sufficient theory is given on instruments to ensure an intelligent appreciation of their uses. Similarly, pupils are taught the basic principles of magnetism, aircraft compasses and the methods of winding and compensating compasses. Students are instructed in the use of radio and radar equipment and a working knowledge of the Morse code is imparted. The student must also learn the proper use of armament equipment. After 150 hours or more of actual flying, both by night and day, on various navigational exercises the navigators receive their wings.

A major portion of the student pilot's course likewise is allotted to briefings and analysis of his flying training. Ground instruction in theory of flight, navigation, meteorology, flight instruments, armament, aviation medicine, aircraft engineering and development and radio procedures, including morse code, all this is aimed at enabling students to obtain maximum benefit from their in-flight training.

A Norwegian prepares for Link Trainer practice.

The pilots must prove themselves capable of carrying out flights (by day and night) using basic flight instruments; cross-country flights using pilot navigation methods; aerobatics; formation flying; emergency landings; controlled descents; radio range and radio compass procedures, and VHF homings in poor visibility.

In advanced flying schools, pilots are required to meet higher standards of accuracy and reliability in carrying out operational exercises such as simulated fighter squadron rapid landing procedure, formation flying, high-altitude, high-speed cross country flights, air interception, VHF homings and fighter tactics. To prepare for squadron operational flying, ground lectures include a more advanced and detailed study of flight instruments, their operation, causes of failure, corrective action and operational limitations. More advanced navigational techniques are taught, stressing high and low altitude flying at high speeds together with added training in the interpretation and integration of weather data and radio aids.

An English student graduates and gets his wings. As a reward, his comrades cut off his necktie.

In the R.C.A.F. training of fighter pilots the emphasis in weapons training is placed on air-to-air firing, but the methods of making effective ground strafing, live boming and rocket attacks are also taught. Pupils are instructed in the use of small arms and in aircraft recognition.

Obstacles of language, rank and custom differences are being overcome by the common desire to fly. A genuine N.A.T.O. spirit of internationalism has been developed in these thousands of Canadian-trained air crew which they will carry on in duties with their national air forces, come peace or war.

N.A.T.O.—2

Air Power, Technology and AGARD

by Major Kemper W. Baker U.S.A.F.

Executive, Combustion Panel, AGARD

The author

The research of today is the development of tomorrow. Within the N.A.T.O. setting, it is the function of the Advisory Group for Aeronautical Research and Development (AGARD) to reduce time slippage to a minimum. This does not imply that time is the only factor to be considered: others include the quest for quality and potential for the future, sometimes at the expense of better weapons today.

AGARD's task is reasonably clear. The objective is to assist N.A.T.O. in obtaining technically superior air forces. Where future potential is not sacrificed or jeopardized, this must be achieved at a cost not greater than would be incurred if member nations were proceeding individually. This approach eliminates duplication and ensures that AGARD operates only in fields not adequately covered otherwise.

Obviously, a priority task has been that of filling the gap created by wartime development which went ahead more rapidly than basic knowledge could be acquired. Examples are aerodynamic instabilities in high-speed aircraft and combustion instabilities in new type combustion chambers. The consequences of such accelerated development have been costly and in some cases fatal. The solution is acceleration of research rather than deceleration of development.

The acquisition of knowledge in order to extend the technological horizons is no less important and can best be achieved by international technical co-operation within N.A.T.O.

Led and stimulated by its Chairman, the world famous scientist-administrator, Professor Theodore von Karman, AGARD has projected its influence into the fields of combustion, wind tunnels, flight testing and aeromedicine. It has also begun to support certain auxiliary activities such as research documentation and research personnel exchange.

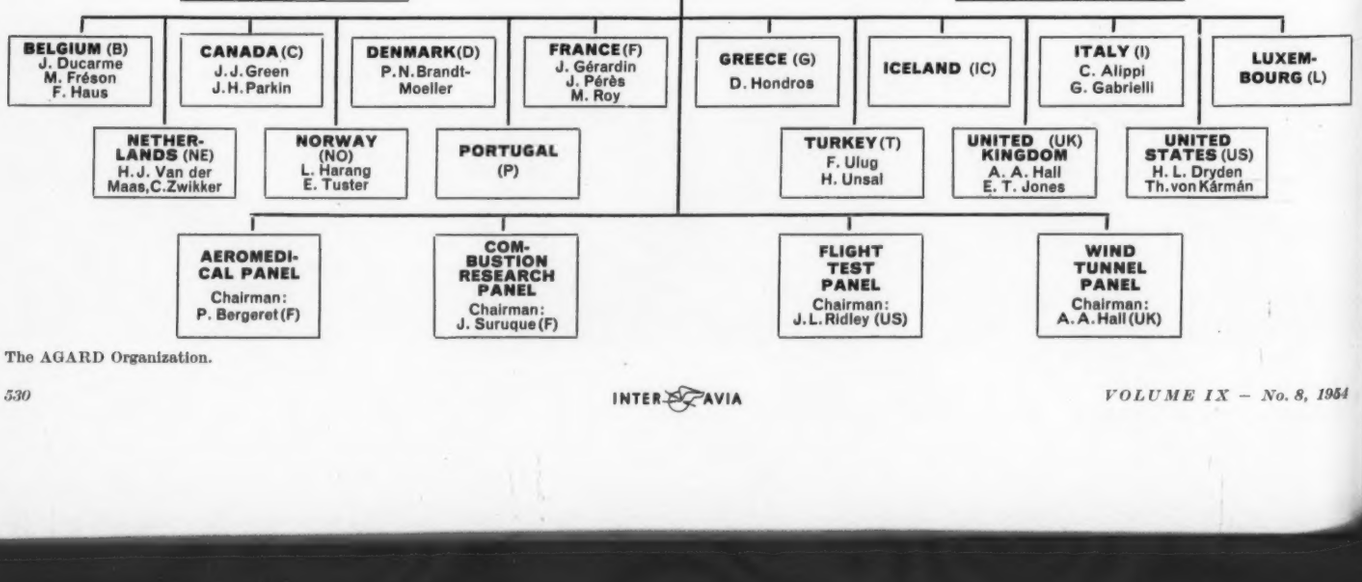
*

When AGARD started operating in the summer of 1952, *combustion* was a "natural" for special attention. The first Allied jet aircraft took to the air in 1941. By 1952, the emotional impact of revolutionary turbo-jet development had dulled. Development proceeded at a normal pace but because spectacular advances were less frequent some experts were led to believe that the turbojet was becoming obsolete. In technical circles emphasis seemed to be going to ramjets, pulse-jets and rockets. Military aircraft requirements kept pushing toward higher speeds and higher altitudes. The sonic barrier had been passed, and scientists began reaching for the temperature barrier.

AGARD Chairman Professor Theodore von Kármán. His philosophy of life is characterized by his statement, "teaching is only an excuse for learning."

Every step of progress raised new questions on combustion. In the piston engine combustion was a rather well defined problem of fuel chemistry, but in the jet engine the story was different. Here combustion was more than simple oxidation in a closed chamber. Painfully it was realized that burning within a high velocity mass flow was a mystery. The simple chemistry processes were complicated by the super-imposition of the aero-thermodynamic processes.

Many important questions are still pending, and only painstaking, well-supported research will provide answers. Take for example the general case of high-altitude combustion. Here, aside from specific problems such as atomization at low pressures and the burning of fuel droplets at reduced pressure, there is great need for systematic examination of practical combustion systems to find out what is the relative importance of the various component processes. What is the influence of Reynolds number? At what level of particle size does atomization cease to



The AGARD Organization.

be an important factor? What is the balance between physical and chemical processes?

Obviously, AGARD cannot tackle the job of clearing up all combustion problems single-handed. The AGARD venture is designed to supplement the work of other national and international groups. Positive results are exemplified by the existence of combustion projects, inspired by AGARD, in the national laboratories of Belgium and Holland. And soon AGARD will sponsor a comprehensive research program in flame stabilization and droplet combustion.

Under AGARD sponsorship, leading international experts prepare technical monographs which constitute major contributions to the combustion science. For example, L. Crocco of Italy is completing a major monograph (so-called AGARDograph) on low frequency instability in rocket motors. B. P. Mullins of Great Britain has recently completed an AGARDograph on the spontaneous ignition of liquid fuels. The AGARD book, "Selected Combustion Problems", is being sought avidly by combustion scientists and technical libraries in all N.A.T.O. countries.

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The whole of the AGARD sponsored program is designed to operate where costly research facilities are scarce and where the ability of the scientist rather than capital can call the tune. Here international cooperation faces the real test—joint ultilization of nationally owned facilities. The smaller the aircraft industry of a country, the greater its need for test facilities so as to remove the risk from the procurement of high-cost production items. *Wind tunnels are no exception.* Certain N.A.T.O. nations, through AGARD liaison facilities, have arranged for the conduct of their own research projects in wind tunnels belonging to other member nations.

It has long been recognized that one of the most serious drawbacks to wind tunnel use was the lack of adequate design and technique information. This is the weakness that AGARD has attacked most strenuously. No one is more aware of this than the Wind Tunnel Panel Executive, *Colonel Paul Bane* (U.S.A.F.), who has eighteen major wind tunnel AGARDographs on his books and scheduled for early publication. Titles include: "Dynamic Stability Techniques in Wind Tunnels" by L. Arnold (U.S.) and J. Valensi (France); "Optical Equipment in Wind Tunnels" by B. W. Holder (U.K.); "Scale Effects at Subsonic and Supersonic Speeds" by I. Abbott (U.S.) and "Drying of Air Used in Wind Tunnels" by M. S. Smolderen (Belgium).

*

Similarly *flight testing* is of interest to all N.A.T.O. countries whether or not they have an aircraft industry. Flight testing is needed not only for research and development but also for aircraft maintenance and for all airborne components, including crews. Vast development and production experience forced Great Britain and the United States, in particular, to formulate standard flight test techniques. For most of the other N.A.T.O. countries, techniques have fallen into many composite patterns if, indeed, any patterns at all. With increased international cooperation and especially because of equipment and personnel exchange within N.A.T.O., the need for a set of international flight testing standards became apparent. As a result, the first *international Flight Test Manual* will soon be distributed within N.A.T.O. A year and a half in preparation, this manual combines the best of the experiences of N.A.T.O. members and provides a common procedure for the measurement and evaluation of performance, stability, control and other pertinent flight characteristics of aircraft. It also includes a catalog of flight test instruments which are in use or available within N.A.T.O. The authors are all recognized authorities in France, Holland, Great Britain and the United States.

To date, AGARD's flight test activity has dealt with the more general aspects of the subject. Now it is starting to get specific. Present planning includes an investigation leading to recommendations for flight test standards for N.A.T.O.'s rotary-wing aircraft, which now include 130 distinct types. Solutions will be obtained from throughout N.A.T.O. for trainer development problems posed by a small N.A.T.O. nation, which has only a moderate aeronautical background but which has embarked upon a significant production program. Icing problems, too, are being attacked by a Flight Test Panel sub-group, and the best possible anti-icing techniques are being evolved for N.A.T.O. adoption. Airworthiness standards are being formulated in collaboration with a N.A.T.O. standardization agency. Until recently the panel's Executive was *Colonel J. J. Driscoll* (U.S.A.F.), who displayed great ingenuity in handling the more puzzling problems.

*

There is little doubt that the effects of present-day flying are critical for the *human body*. The better the performance of the aircraft, the greater the needs for safeguarding and protecting the crew. In fact, man himself has become a limiting factor in aircraft design. The problems result from the effects of "G" pressure, temperature, oxygen, technical complexity of equipment.

It was logical that AGARD establish well conceived crew selection methods and criteria as a primary goal. An Aeromedical Panel symposium brought to light such constructive data on the selection subject, particularly with respect to psychological, physiological and clinical criteria. The same symposium pointed up deficiencies in the knowledge of vision and cardiovascular functions. Subcommittees are hard at work to crystallize all available knowledge on crew selection and make it available to N.A.T.O. nations.

Members of the AGARD Aeromedical Panel attending a demonstration of the Ejection Seat Trainer at the Centre d'Essais en Vol, Brétigny, France.

Interchangeable use of aircraft in N.A.T.O. has precipitated design problems. Within N.A.T.O., the physical characteristics of crews vary considerably. In view of the different average heights, weights, arm and leg lengths, etc., it is a serious question as to whether crew interchangeability can be taken for granted. Consequently, the cataloging of anthropometrical data has become the important task of another subcommittee.

Major George Zinnemann (U.S.A.F.), Panel Executive, has carefully reiterated that many important aeromedical problems are yet to be solved. For example, the Panel program includes decompression sickness, survival feeding and color blindness.

*

Finally, AGARD's *Documentation Committee and Exchange Program* activities are evidences that proper attention is being paid to the educational side. Largely on his own initiative, the Exchange Program Director, *Mr. Rolland Willaume,* has arranged an impressive list of scientific personnel exchanges ranging from several days to a year. This experiment in international relations has a great growth potential if the universities and national laboratories continue to participate so willingly.

The Documentation Committee has been extremely active due to the enthusiasm of committee members as well as the Committee Executive, *Miss Elizabeth Connelly.* This group has come up with impressive projects for increasing the availability of research reports, improving abstracting services and for the initiating of the use of standard index or catalog cards in technical publications. Another project is the publication of a dictionary of aeronautical terms in seven languages. This dictionary should be distributed early in 1955.

From all these functions flow internal and external demands for coordination, direction and scientific counsel. These are dealt with by *Dr. F. L. Wattendorf,* Secretariat Director, who has been with the organization from the outset.

AGARD stresses inexpensive equipment. Shown right of bucket is Dr. D. B. Spalding of Cambridge University (U.K.) demonstrating an ingenious new method of measuring flames, of his own design.

What's in the Air?*

AVIATION POLITICS

• Franco-Russian air transport agreement

An air transport agreement signed in Moscow betwen the Soviet Union and France provides for the opening of an air service between Paris and Moscow, the Moscow-Prague stage being flown by Russian aircraft, and the Prague-Paris stage by French aircraft. The agreement was signed by French Ambassador Louis Joxe on behalf of France and by Marshal Zhavoronkov, head of Aeroflot, for the U.S.S.R. — A French delegation led by Maurice Lemoine, Secretary General of Air France, has now gone to Prague to discuss with the Czech Government the details of the Paris-Prague service (Douglas DC-3 on the French side and Ilyushin Il-12 on the Czech).

• I.C.A.O. Legal Committee

The International Civil Aviation Organization's Legal Committee is to hold its 10th Session in Montreal on September 7th, 1954.

• Canadian Government changes

The following reshuffle in the Canadian Government has been announced from Ottawa: *Defense Minister* Brooke Claxton has been replaced by *Ralph Campney* (Claxton becomes Vice-President of an insurance company), and *Transport Minister* Lionel Chevrier (who takes over direction of the St. Lawrence waterways project) is replaced by *George Marler*.—The *Deputy Transport Minister*, Charles W. West, has also resigned and joined the St. Lawrence project; his place has been taken by *John R. Baldwin*, hitherto Deputy Transport Minister for Air Services and Chairman of the Air Transport Board.

SERVICE AVIATION

• U.S. Pacific Air Force

Major General Sory Smith has been appointed to command the U.S.A.F.'s new Pacific Air Force, with headquarters at Hickham Field, Hawaii. General Smith has been Chief of Air Force Information Services since 1950. He will now represent the U.S.A.F. on the Pacific Joint Staff at Pearl Harbour.

• U.S. Air Force rotation programme for Far East

The U.S. Air Force has inaugurated a similar wing-rotation programme in the Far East to that already operating in Europe. The first unit to move is the 98th Medium Bomber Wing, which is returning to Lincoln Air Force Base, Nebraska, for refitting with Boeing B-47 *Stratojet* six-jet bombers.

• Starfire... star in rocket firing

The Lockheed F-94C *Starfire* two-seat jet fighter took first place in the first radar rocket competition organized by the U.S. Air Force. All firing was radar and radio-controlled, with competing crews starting from ready-room "alert" and scrambling under ground radar direction to target altitudes of 20,000 ft. and 30,000 ft. Each team made twelve sorties at each altitude, using a target 9 ft. by 45 ft. An F-94C team from Moody Air Force Base, Georgia, won top honours with 10,400 points.

General Silvio Napoli, Inspector General of Telecommunications (right) and *General Ranieri Cupini*, Commander of the 56th Tactical Air Force, have been promoted to full Generals (highest rank in the Italian Air Force). Both took part in the 1931 and 1933 Atlantic formation flights led by General Italo Balbo.

• Berlitz School for U.S.A.F. personnel

All U.S. Air Force officers and enlisted men stationed in Germany, France, Italy and North Africa are to take a compulsory 30-hour course in the local languages. Present strength of the U.S.A.F.E. is about 80,000 officers and men.

AIR TRANSPORTATION

• New Secretary General for I.A.T.A.

A. Laurence Young has been appointed Secretary General of the International Air Transport Association. During the past eight years Young has served as Secretary of the I.A.T.A. Traffic Committee and more recently as Assistant to the Director-General. His new appointment is subject to confirmation by the Association's Annual General Meeting to be held in Paris in September.

• K.L.M. President... «Too many good aircraft types»

General I. A. Aler, President of K.L.M. Royal Dutch Airlines, who has been having talks in Paris with the French authorities and with the heads of Air France, told the Association of French Aviation Journalists that closer cooperation between the European airlines is essential. A common procurement programme might be the first step on this road; at present the airlines were offered "too many good aircraft types."

Air Commodore Michael Watson has resigned from his post as Director of Signals, Air Ministry, to head *Decca Radar's new Radar Systems Division*. The new Division will handle military radar systems, civil air aids, radar links and meteorological radar.

• The economy of helicopters

At the Stuttgart General Meeting of the German Helicopter Study Group (Deutsche Studiengemeinschaft Hubschrauber) Chairman Dr. Treibel stated that the problem of economic operation of rotary-wing aircraft cannot be solved until twin-engined commercial helicopters for 40 passengers are available.—For example, Sabena's Brussels-Bonn helicopter feeder service requires substantial subsidies and is only run to get additional passengers for the Atlantic services and to provide experience of helicopter operations.

• ...Ostermans thinks otherwise

The Swedish charter company Ostermans Aero AB, which has a fleet of eight Bell 47D-1 helicopters for agricultural services and search and rescue operations, has ordered a Sikorsky S-55 helicopter for delivery in August or September 1954. It is to be used primarily for ambulance purposes... However, Ostermans has postponed the opening of a projected experimental passenger helicopter service between Sweden and Denmark until a helicopter for at least 15 passengers is available.

INDUSTRY

• France forbids public prototype demonstrations

The French Air Ministry has forbidden public demonstrations of prototypes and pre-production

* Extracts from *Interavia Air Letter*, daily international news digest in English, French and German. All rights reserved.

Pakistan International Airlines was formally inaugurated at a colourful ceremony at Karachi Airport. Maulana Ehtishamul Haq, a leading Muslim Divine, read passages from the Koran and blessed the first Lockheed *Super Constellation* of the new company.

Sir Frederick Handley Page (right) handing over to *Admiral Todomu Nakamura*, Manager of C. Itoh & Co. Ltd. (Handley Page agents in Japan), the Certificate of Airworthiness for the first of two *H. P. Marathons* to be used by Far East Airlines on its domestic routes.

aircraft, as a result of a series of accidents in recent months. In future only French Air Force pilots will be permitted to fly in public aerobatic demonstrations.

• Bane and Chanute Awards

Two top U.S. aviation awards were presented at the summer meeting of the Institute of the Aeronautical Sciences in Los Angeles. The Thurman Bane Award, for "outstanding accomplishments in the field of personnel parachute development", went to Dr. Helmut G. Heinrich, former German scientist now a U.S. Air Force research engineer at the Wright Air Development Center. Dr. Heinrich is credited with the design of the "Personnel Guide Surface" parachute now being manufactured by Pioneer Parachute Co., of Manchester, Conn.—The Octave Chanute Award went to George E. Cooper, Assistant Chief, Flight Operations Group, Ames Aeronautical Laboratory, National Advisory Committee for Aeronautics, for "outstanding piloting and research at transonic and supersonic speed, resulting in increased understanding of transonic air flows and problems of stability, control and buffeting." Cooper discovered a technique by which the sun may be used to visualize shock waves on aircraft in flight at transonic speeds.

• W. C. Jordan leaves Hughes

William C. Jordan, whose appointment as Vice President and General Manager of Hughes Aircraft Co., was announced eight months ago, has already resigned from the Company. Reason given is that Jordan had to prepare for a surgical operation in August. Formerly with Hiller Helicopters Inc., and a one-tine president of Curtiss Wright Corp., he joined Hughes Aircraft last October 15th, after a general exodus of leading company officers resulting from a series of policy disputes with Howard Hughes. He succeeded Lieutenant General Harold Lee George, who had joined Hughes as Vice President and General Manager in 1948.

FLYING EQUIPMENT

• On June 28th the first *Douglas RB-66A* twin jet reconnaissance bomber began flight testing, with Douglas test pilot George R. Jansen at the controls. The aircraft took off from the firm's Long Beach airfield and was flown to Edwards Air Force Base, California, for further tests.—The RB-66A is the U.S.Air Force version of the Navy's A3D *Skywarrior* low level attack bomber; it has a swept wing and swept tail unit; two Alison J-71 turbojets of 10,000 lbs. static thrust are fitted in pods underneath the wings.

• *Convair* is flight testing four *YF-102* supersonic interceptors. The F-102A production model, already in production, will differ from its predecessors in a slightly redesigned fuselage, particularly in the region of the wing-fuselage junction. Object: to reduce compressibility interference and improve performance.

Two versions of the *Rotor-Craft RH-1 Pinwheel* rocket-powered one-man experimental helicopter are being tested. One has a small rudder and the other a tail screw. The latter version is being tried out by the U.S. Navy. After the test flights the temporary landing gear will be removed, and the whole machine, which weighs only 100 lbs, will be carried strapped to the pilot's back like a rucksack. The "landing gear" will be the pilots legs.

• The first phase of the flight test programme with the *Lockheed XF-104* stripped single-seat fighter (Wright J-65 *Sapphire* turbojet) has been completed, the U.S.Air Force announces. The XF-104 is capable of exceeding Mach 1 in level flight.

• The version of the *North American Super Sabre* now in production is the *F-100A*, a day fighter. Other versions planned for quantity production are the F-100C (fighter-bomber) and *F-107* (formerly F-100B; all-weather fighter).

• Although the *Sikorsky XHR2S-1* helicopter was originally developed for the U.S. Marine Corps for use as a heavy assault transport, the type is now arousing considerable interest among U.S.Army circles. A programme has been approved for the production of roughly 250 of these helicopters for the Army (designation H-37). The programme will be completed in five years.

Società Piaggio, Genoa, participated in the "Around Italy Flight", held in the second half of July, with its new Piaggio P. 149 fourseater sports and personal aircraft. At the controls was ex-Luftwaffe General Galland, former German Air Force Fighter Chief, now back in Europe from Argentina.

• The U.S.Navy announces development of two new experimental helicopters with rocket-powered rotors; the *RH-1 Pinwheel* of *Rotor-Craft Corp.*, Glendale, Calif. and the *KH-15* of Kellett Aircraft Corp., Camden, N. J. Both are very light one-man machines with mono-propellant rocket motors at the blade tips (liquid propellant). The motors are made by Reaction Motors Inc., of Rockaway, N. J.

• Good progress is being made in construction of the *Folland FO.139 Midge*, a ground attack version of the FO.141 *Gnat* light single-seat fighter. The FO.139 prototype is fitted with an Armstrong Siddeley *Viper 101* turbojet and is scheduled to begin flight testing before this year's S.B.A.C. Display at Farnborough. Production versions of the *Midge* and *Gnat* will probably have Bristol *Orpheus* turbojets (4,000 to 5,000 lbs. thrust).

• The prototype of the *Hunting Percival P.84 Jet Provost* two-seat jet primary trainer began flight testing at the end of June, Hunting Percival Aircraft Ltd. announces.

• The French S.N.C.A. du Nord has begun flight tests with the *Nord 3201* primary trainer. Fitted with a SNECMA 4 L 22 engine of 170 h.p., the Nord 3201 has a cruising speed of approximately 127 m.p.h. and an endurance of 3 hours.—A second prototype is nearing completion. This model has the same airframe as the first prototype, but is fitted with a 240 h.p. Argus engine.

The *Nord 3201* primary trainer, of which a preliminary batch of thirty is being built by S.N.C.A. du Nord. It has full aerobatic qualities and a gross weight of 2,095 lbs.

POWER PLANT

• Boeing announces a new small gas turbine, the *Boeing 502-10*, a development of earlier models of the 502 turbine. The new engine is reported to have 65 h.p. more power for a fuel consumption 25% lower. Both power increase and consumption reduction have been obtained by refinements to the compressor and turbine and by a higher compression ratio.

• The *Pratt & Whitney J-57* turbojet delivers a take-off static thrust, with reheat, of 14,500 lbs. Engines of this type are used in the North American F-100, McDonnell F-101, Convair F-102 and Douglas F4D.

• The following data have been released for the Japanese *Kawasaki KAE-240* 6-cylinder air-cooled horizontally-opposed engine: take-off power 260 h.p. (3,400 r.p.m.) at sea level; rated power 240 h.p. (3,000 r.p.m.) at sea level; bore 4.9 ins; stroke 3.9 ins; swept volume 448 cu. ins; compression ratio 7.25; length 48.6 ins; width 26.2 ins; height 33.7 ins; dry weight 440 lbs; fuel 80 octane.—KALE-240 engines are to be used in the Kawasaki KA-1 and KAT-1 aircraft (communications aircraft and trainers) and the Kawasaki-Bell 47D helicopter.

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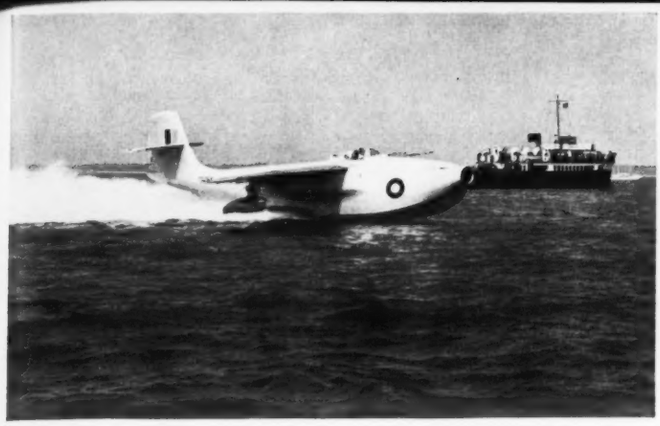
Great Britain	£1 15s. 0d.	Interavia (U.K.) Ltd., Standbrook House, 2-5, Old Bond Street, London, W. 1.
Holland	Hfl.28.00	Henk A. Jansen, Olympiaplein 84, Amsterdam Z.
Italy	Lit. 4060	Interavia, 30, Via San Marino, Rome 7.23.
South Africa	£2 6s. 0d.	Interavia, P.O. Box 6073, Johannesburg.
Spain	Ptas 280	Saenz de Pazos, Donoso Cortés 85, Madrid.
Sweden	Kr.35	Interavia, Postbox 29, Linköping.
Switzerland	Fr.28	Interavia, Corraterie 6, Geneva.
Uruguay	Pesos 23	R. F. Besnard, Edificio Artigas, Rincon 487, Montevideo.
U.S.A.	$7	Interavia, 185, Madison Avenue, New York 16, N.Y.



1947 : Saunders-Roe SR/A1 fighter flying boat ; power plant two Metrovick *Beryl* turbojets of 3,850 lbs. thrust each ; gross weight 16,200 lbs ; four 20-mm cannon in the nose.

1954 : Convair XF2Y-1 *Sea Dart* naval fighter prototype with delta wing and hydro-skis ; power plant two Westinghouse J-34 turbojets of 4,700 lbs. thrust each.

"New Look" in Weapons Planning — IV :*

Water-Based Interceptors

The first article of the series (No. 7, 1954 : " Reducing the size of Take-off and Landing Bases ") investigated how land-based fighters can be freed of their dangerous dependence on concrete runways. Today's massive bases would naturally be first-rank targets.

Another means of protection from atomic attack would be to develop *water-based interceptors*, which could take off from Europe's many lakes, dams, harbours or even rivers. Map and table below show that there are around 60 suitable water surfaces between latitudes 43 and 49 and longitudes 1 and 10 E. Although natural water surfaces are impervious to bombing, the same is not always true of artificial lakes, as witness the R.A.F. raids on the Möhne and Eder dams in the last war. Nevertheless the protection of hydraulic power stations would be substantially improved by stationing fighter squadrons on the dams ; if the " base " were destroyed, there would still be sufficient alighting areas available in the vicinity.

This type of ground organization would be invulnerable. At the moment, however, suitable flying equipment is lacking. It is true that the British firm of *Saunders-Roe, Ltd.* built and tested, as long as seven years ago, several prototypes of the Saro SR/A1, a jet-powered fighter flying boat with a speed of " more than 500 m.p.h. ", but this line of development was not followed up. (There have been plans for more powerful engines and replacement of the straight wing with a swept wing.) It may be that the Saro flying boat is not entirely suitable for high-seas operations—two prototypes were lost during the tests—but a modernized version of the design would doubtless be adequate for inland water surfaces.

A new type of fighter flying boat has been brought out by *Consolidated Vultee Aircraft Corp.* in the Convair XF2Y-1 *Sea Dart* twin-jet delta-wing fighter fitted with hydro-skis. No production contract has been awarded for this prototype either. Thanks to its *retractable* hydro-skis (reduced drag) the *Sea Dart* should have high speeds and good rate of climb. Take-off difficulties, however, have not yet been overcome. According to reports, take-off runs of up to 10,000 ft. are required. Convair is therefore considering replacing the two hydro-skis with a single ski and fitting a single, more powerful engine of at least 10,000 lbs. thrust (plus reheat) instead of the two Westinghouse J-34s, so as to reduce weight.

*

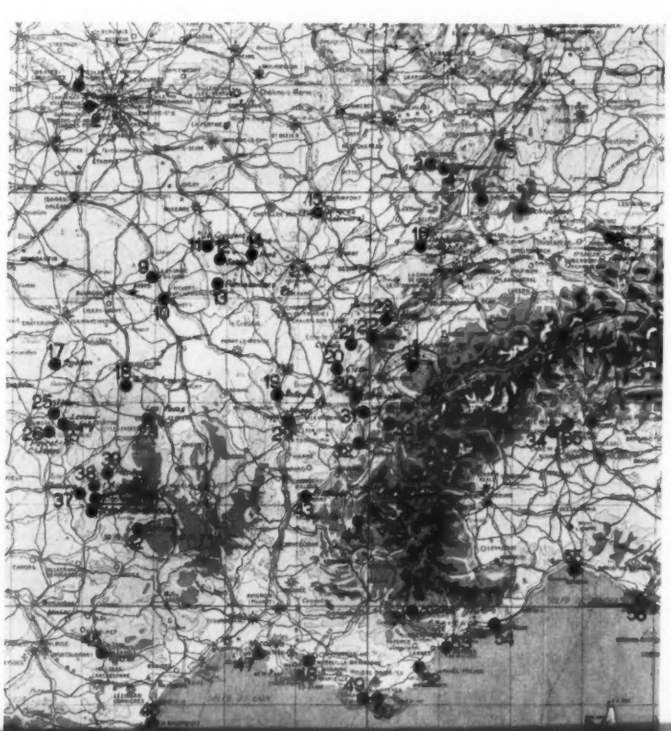
Although America, despite her distance from the " front ", is working on a water-based fighter, there have been no similar projects —except the Saro—in Europe. Yet as things are today, Western Europe would be the first target for an air offensive. It would therefore not be surprising if designs for tactically efficient water-based fighters were to come out of European project offices.

* Continuation of the series of articles begun in the last issue (No. 7 1954).

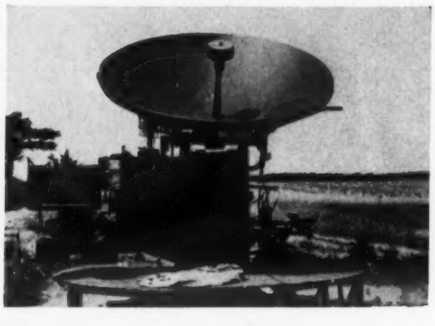
Some suitable water areas for interceptors in South-West Europe (excluding Switzerland)

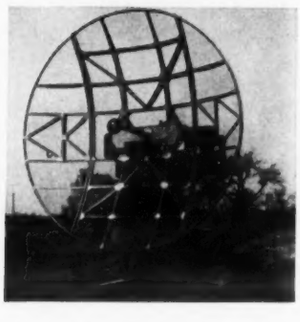
(from a paper by S.N.C.A. du Nord)

No.	Place	Approximate dimensions (in m.)	No.	Place	Approximate dimensions (in m.)
1	Meulan-Les Mureaux	1300 × 310	30	Génissiat (dam)	5000 × 500
2	Etang de Saint-Quentin	1200 × 300	31	Val de Fier (dam)	3600 × 350
3	Lac de Gérardmer	2000 × 500	32	Le Bourget Lake	16 000 × 1600
4	Lac de Lorgemer	1600 × 400	33	Lake Annecy	6000 × 1000
5	Neuhof-on-Rhine		34	Lake Maggiore at Sesto Calende	
6	Rhine below Basle				
7	Schluchsee		35	Lake Varése	
8	Lake Constance		36	Lake Como	
9	La Charité-sur-Loire	1200 × 400	37	Chastang	5000 × 400
10	Nevers-Sermoise	500 × 400	38	L'Aigle (dam)	4500 × 400
11	Le Crescent (dam)	2000 × 350	39	Marèges (dam)	8000 × 500
12	Sottons Reservoir	2000 × 1800	40	Enchanet (dam)	3000 × 450
13	Pannessières (dam)	6000 × 400	41	Saint-Etienne-Cantalès basin	2000 × 400
14	Du Pont Reservoir	1300 × 300			
15	Haute-Marne basins		42	Sarrans basin	4500 × 400
16	Dampjoux-Grosbois (dam)	4000 × 450	43	Pizançon (dam)	2800 × 350
			44	Le Sautet (dam)	4400 × 500
17	Eguzon (dam)	3000 × 350	45	Vintrou (dam)	3600 × 500
18	Teillet-Argenty Basin	4500 × 300	46	Perpignan-La Salanque	1200 × 1000
19	Belleville (dam)	1200 × 500	47	Etang du Vaccarès	12 000 × 10 000
20	Cize (dam)	6000 × 400	48	Marseille-Marignane	5000 × 5000
21	Lac de Chalain	2800 × 800	49	Toulon-Saint-Mandrier	
22	Lac de l'Abbaye	2000 × 350	50	Hyères-Palyvestre	
23	Lac de Saint-Point	6600 × 500	51	Castillon (dam)	6000 × 800
24	Lake Geneva at Evian	10 000 × 2000	52	Saint-Raphael	
25	Saint-Marc Basin	2600 × 400	53	Antibes	600 × 600
26	Peyrat-Le Château Basin	3200 × 600	54	San Remo	
27	Lavaud-Gelade reservoir	2000 × 350	55	Genoa	
28	Les Fades (dam)	4200 × 300	56	La Spezia-Cadimare	
29	Jonage (river port)	1800 × 600	57	Bastia-Béguglia	



The first Douglas F4D **Skyray** naval interceptor off the production line took off on its maiden flight from Los Angeles International Airport on June 5th, shot steeply upward and then went into supersonic level flight. The aircraft has a Pratt & Whitney J-57 turbojet of about 10,000 lbs. s.t., which replaced the prototype's Allison J-35 of approximately 6,000 lbs.





Figs. 1-4: German radar equipment for anti-aircraft defence. Left to right: 1- First model of **Würzburg A** aircraft reporting equipment (1939; wavelength 53 cm); 2- **Würzburg C** fire control equipment with defocussed rotating dipole (1940; wavelength 53 cm); 3- **Mannheim** fire control equipment (1942; wavelength 53 cm); 4- **Marbach** fire control equipment (1945; wavelength 9 cm). The **Marbach** was operated and read from a remote, protected service truck.

"New Look" in Weapons Planning — V

Radar Problems, Yesterday and Today

BY DIP. ING. TH. PEDERZANI, ULM

The author, Chief Development Engineer with Telefunken G.m.b.H. during the war and head of several working groups in the "Special Radar Committee", bases his remarks on the level reached in German radar engineering at the end of World War II, though he also discusses certain developments of the post-war years. The editors have added pictures from Interavia's files and the latest available data from American, British and French manufacturers, which provide indications of the present position in military radar technique in the West. The article is also of topical interest in that development of Russian radar has been very largely influenced by captured German research reports and equipment. Editors.

RADAR MISSIONS IN WARTIME	
On the ground	**In the air**
Location of individual air targets	Target pursuit for fighters
Fire control for batteries	Fire control for fighters and bomber tail posts
Information on air situation	Target search over land and water
Fighter control	Radar navigation
Guidance of ground-to-ground rockets	Bomb aiming
Guidance of anti-aircraft rockets	

RADAR TASKS IN PEACETIME	
On the ground	**In the air**
Tracking meteorological balloons	Measuring altitude
Detection of bad weather zones	Distance measuring
Air traffic control	Radar navigation
Radar landing aids	
Supervision of ground movements	

The number of tasks that have to be solved by means of radar is constantly growing. The accompanying table gives some idea of the position, though it includes only active tasks. Passive equipment and jamming equipment, as well as general radio navigation aids have been ignored.

It is not possible, within the narrow scope of this article, to go into details of all radar missions. The questions that have been chosen for closer discussion are those arising from the detection of individual aircraft, from the fire control of anti-aircraft batteries, and finally from the provision of overall pictures of the air situation.

LOCATION OF INDIVIDUAL AIR TARGETS BY RADAR AND FIRE CONTROL EQUIPMENT

Detecting the target: For rapid detection of a target the radiation diagram of the

Fig. 5: Principle of radar distance measuring: Radar equipment **F** emits pulse **S** which is reflected by the targets (reflected pulses **R1** and **R2**). As **S** is emitted a point of light starts out from twelve o'clock position on the cathode ray tube and moves at steady angular speed in the direction of the arrow. When reflected pulses **R1** and **R2** return, the beam is deflected in the manner indicated, so that the distance can be read off from the circumference and marked by a mechanical pointer. The process is repeated several thousand times a second.

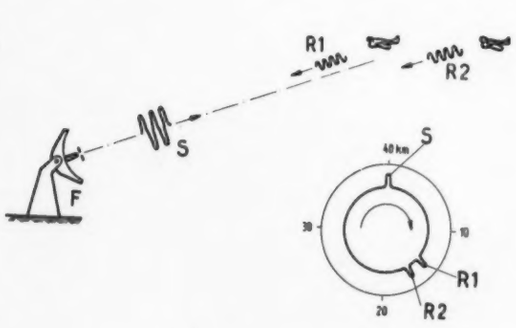


Fig. 6: Measuring and transmitting the distance value by means of **"dark spots".** Instead of marking the position of the reflected pulse by a mechanical pointer, a blocking pulse, set by phase shifter **S**, is used. This appears as a gap (dark spot) in the line of light on the cathode ray tube. Each full revolution of **S** provokes a full revolution of the dark spot. The phase shifter is turned until the dark spot appears over the reflection pip (**a**), and the latter is followed as the target moves (**b** or **c**). The measured distance is passed to the fire control equipment by means of transmission equipment **U**, which is coupled with **S**.

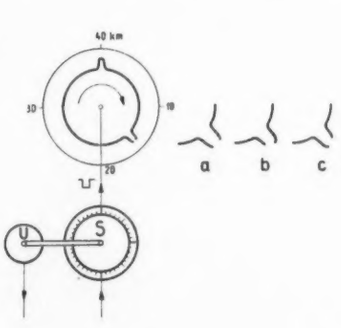
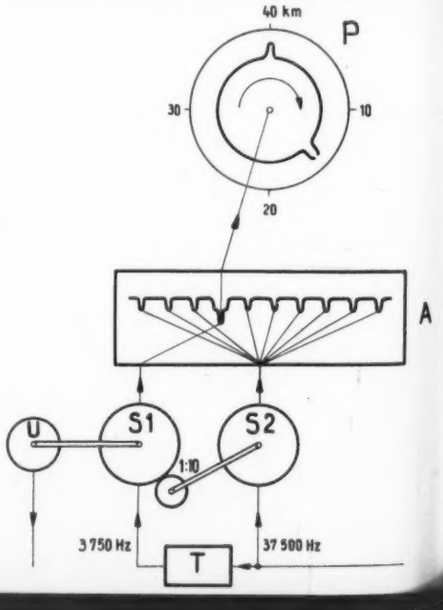


Fig. 7: Principle of acurate distance measuring: The blocking pulse which produces the dark spot in the polar tube is formed by periodic selection of a given pulse from a series of ten times the frequency. The basic frequency (3,750 c/s) passes through phase shifter **S1**, the ten-/fold frequency (37,500 c/s) through phase shifter **S2**. Every tenth pulse is "counted out" in selector **A**; the time error in the older system (fig. 6) is thus reduced by 90%.



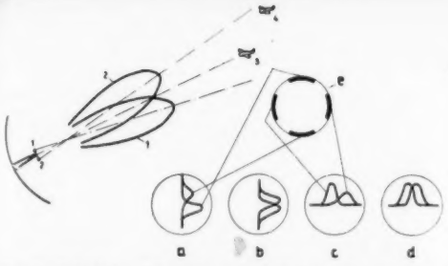


Fig. 8: Principle of " split presentation " with eccentrically rotating dipole: Aircraft 3 has been accurately located and produces picture **b** in the altitude tube of the fire control equipment, and picture **d** in the azimuth tube. Aircraft 4, on the other hand, is not correctly positioned as can be seen from indications **a** (altitude tube)) and **b** (azimuth tube).

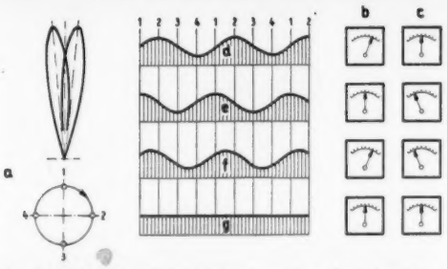


Fig. 9: Principle of instrument reading for aircraft location in the Mannheim fire control equipment: Dipole **(a)** rotates eccentrically. If the target has been correctly measured the two instruments for azimuth **(b)** and altitude **(c)** show zero (case **g**). In case **d** the target is slightly further to the right, in case **e** slightly higher and in case **f** to the right and higher.

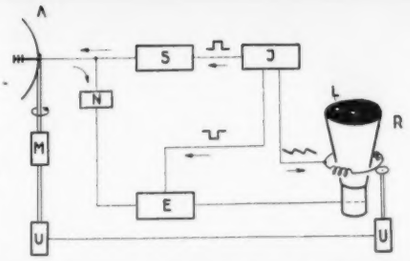


Fig. 10: Diagram of a panoramic unit with rotating aerial. A- aerial ; M- motor driving aerial ; N- blocking device for transmission pulse (Nullode) ; S- transmitter ; J- pulse generator ; E- receiver ; R- cathode ray tube ; L- light spot ; U- transmission system for synchronizing the rotation of the magnetic deflection system of the cathode ray tube wirh the aerial.

aerial must be sufficiently broad. In the *Würzburg A* apparatus (*fig. 1*) this width for example was 10 degrees, which was a good compromise, with the 53-cm wavelength used at the time, between transmitter power and aerial dimensions. As transmitter power was only a few kilowatts, large aerials were necessary in order to obtain sufficient range. On the other hand, the large aerial used with *metre waves* prevented excessive concentration of the beam. The same applied to the *Lichtenstein* airborne search radar *(fig. 11)* which worked on metre waves between 2 and 3m. It was only towards the end of the war that *centimetre waves* were used by the German anti-aircraft artillery, as for example in the *Marbach* fire control equipment *(fig. 4)* and the related *Kulmbach* surveillance radar *(fig. 13)*. Today's surveillance radar and fire control equipment (cf. *fig. 15*) use only centimetre waves, as does all airborne radar (cf. *figs. 14 and 17*).

Distance measuring: Most systems work on periodically repeated pulses whose *travel time out and back* indicates the distance. They require very accurate time measuring equipment, working in tenths of a milli-second. A suitable aid here is the cathode ray tube invented by the German physicist *Ferdinand Braun*. First used by Breit and Tuve in 1926 for ionosphere measurements, it was incorporated in practically all radar instruments during the last war and is still widely used today. For example, the *Würzburg A* ground radar equipment developed in 1939 (later converted into the *Würzburg C* fire control equipment) had a radially deflected cathode ray tube whose operation is shown on *fig. 5*. Other instruments, such as the *Freya* used in the aircraft reporting service, and the *Lichtenstein* night fighter airborne radar, used a linear deviation of the cathode ray geared to the travel time. — The proportion of this time deviation was not always accurate, however. In the *Lichtenstein* the distance measuring scale was therefore shown electrically in the form of light spots, which helped to eliminate deviation and tube errors. — The greatest degree of accuracy in distance measurement was naturally required by the *anti-aircraft batteries' fire control equipment*. Here, in addition, distance values had to be transferred to the computer or gun director. — The basic principles of this method, used in the *Würzburg C (fig. 2)* and *Mannheim (fig. 3)*, are explained in *fig. 6*. The method of presentation chosen also showed the " tendency " of the target range, i.e., it made it possible to judge whether the distance was increasing or decreasing (varying length of arms at a, b and c). A further improvement in distance measuring was provided by the arrangement in *fig. 7*, with the aid of which the inaccuracy of the phase shifter could be reduced to one tenth. The *Würzburg D* fire control equipment built on this principle in 1942 worked with an accuracy of ± 5 m, regardless of the distance involved. The equipment thus obtained an accuracy of almost 0.1 % for a distance of 25 miles (40 km).

Speed measuring: In many cases it is important to know not only the distance but also the rate of change in distance, i.e., the speed of the target. This is particularly the case with the anti-aircraft artillery, which must calculate its lead values according to this speed. During World War II speeds were still measured by computers working on the differentiation of the time-distance curve. If, however, this curve is not steady, even the first differential quotient (speed) contains serious errors, not to mention the second (acceleration). Attempts were made to eliminate this error by mechanical aids, the so-called " travel-and-speed gears ", though radar technique also enables speed to be measured direct, with the aid of the Doppler effect. As the energy reflected by the aircraft has a higher frequency when the aircraft is approaching and a lower frequency when it is departing, the target's speed can be measured from the difference between transmission and reception frequency. Lead values for the anti-aircraft artillery can thus be greatly improved in accuracy. The method is also used to check the speed of ground vehicles and may similarly be of value in commercial aviation.

Fig. 11: The German **Lichtenstein SN 2** airborne search radar for night fighters used wavelengths between 2 and 3 m. Aerial dimensions were correspondingly large.

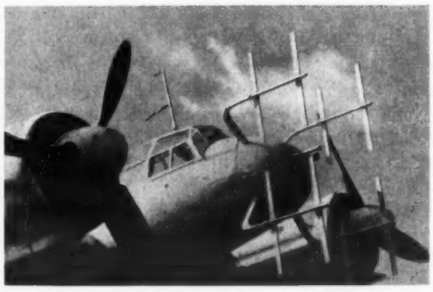


Fig. 12: German **Riese** fire control and night fighter control equipement : wavelength 53 cm ; mirror diameter 25 ft. (7.5 m) ; total weight 18 tons ; range 25 to 35 miles.

Fig. 13: The change-over to centimetre waves led (on the German side) to the **Kulmbach** panoramic equipment : wavelength 9 cm ; aerial length 23 ft ; range 12 to 20 miles. It was used to feed the **Marbach** fire control equipment, which worked on the same wavelength (fig. 4).

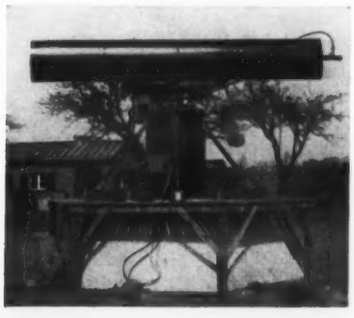


Fig. 14: Modern airborne search radar instruments produced in Canada and the United States are carried in the Avro-Canada CF-100 MK. IV **Canuck** all-weather fighter. They work on wavelengths of a few centimetres and can be fitted, complete with aerials, in the fighter's nose (diameter roughly 4 ft.).

Fig. 15: American fighter control equipment of latest design, as produced by Bendix, General Electric and others : wavelength 10 cm and 3 cm ; very long range.

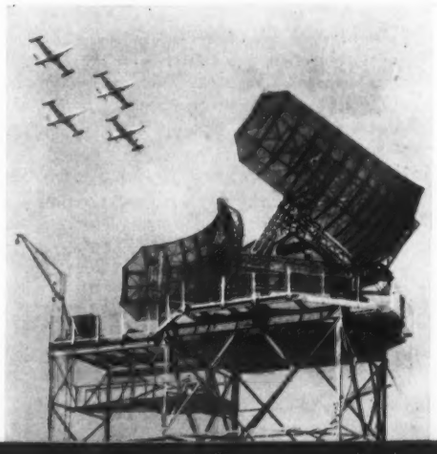


Fig. 16 : The Douglas A4D-1 **Skyhawk** (no folding wings), the U.S. Navy's latest carrier-based combat aircraft and A-bomb carrier, has search radar for ships.

Fig. 17 : The search radar in the Douglas A4D-1 **Skyhawk** is of dwarf proportions, as this comparison between its water-tight aerial housing and the size of Douglas Chief Engineer E. H. Heinemann shows.

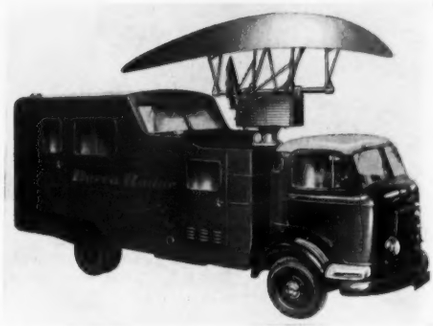


Fig. 18 : Decca 424 mobile airport panoramic radar, developed by the British firm of Decca Radar Ltd., for fighter bases and small civil airports : aerial rotation speed 24 r.p.m ; carrier frequency 9,375 mc/s ; range 20 miles ; altitude range 9,000 ft. (2,800 m).

Direction finding : If the aerial of a radar apparatus is set to the maximum of the reflected energy, this provides a rough direction indication. However, the coarser the D/F system, the simpler will be search operations. Whereas *search* always requires a broader radiation pattern, accurate *location in azimuth and elevation* needs the narrowest possible radiation pattern. The first *Würzburg* instruments had a pattern width (half width) of 10° and obtained direction finding accuracies of ± 2°. For an aircraft reporting instrument this was sufficient, though not for fire control equipment. Moreover, the " tendency reading " was also required for fire control instruments, so that the target could be tracked constantly.

The demand for more accurate direction finding plus tendency indication for fire control equipment was met by the so-called " *split D/F* " system, the basic principle of which is shown in *fig. 8*. The radiation dipole lay eccentrically from the focal point of the paraboloids and rotated ; the reflected energies picked up in the upper, lower, right and left position of the dipole were presented separately. In this way right could be compared with left and top with bottom. If the target was exactly in the mirror axis all pips were the same size ; otherwise the mirror had to be moved accordingly. With this system of split presentation measuring accuracy was increased to about 0.15.° Further improvements were obtained by increasing the *Würzburg* diameter from 10 ft. to 25 ft. (3 m to 7.5 m ; *fig. 12*) for the same wavelength, and by changing the wavelength from 53 cm to 9 cm in the *Marbach* equipment, which had a mirror diameter of 15 ft. (4.5 m ; *fig. 4*).

In direction finding, too, development was moving towards automatic follow-up, for which the split D/F procedure was not suited. Efforts were also being made to replace the cathode ray tube with direct reading instruments, a line of development which was later found to be not very profitable. The *Mainz* and *Mannheim* fire control units *(fig. 3)* designed on this basis utilized the rotation of the eccentric dipole to compare the phase of the modulation in pulse amplitude produced by the rotation, with the fixed phase of an attendant " azimuth generator " and " altitude generator " *(fig. 9) :* when the target had been correctly centred, azimuth and altitude instrument both showed zero, otherwise the aerial mirror had to be moved in traverse or elevation.

Tracking the target : If the target is to be followed constantly, the instrument must show whether and in what direction the measuring value is changing. In assessing fire control equipment, therefore, its static accuracy is not the only decisive factor. The error arising in tracking the target must also remain small ; i.e., dynamic accuracy must be high enough.

This is where engineering limitations come to light. In this respect radar is much less efficient than the human eye, which immediately perceives any change in the position of an aircraft, e.g., the beginning of a turn. Radar cannot detect such movements until an actual alteration in range or azimuth has taken place. This weakness can, however, be compensated by the faster reaction capacity of the automatic follow-up. Hence all fire control equipment for use against aircraft and rockets today has such follow-up devices. Measuring values are fed without human intervention to a computer, which automatically lays the guns or launchers.

PANORAMIC EQUIPMENT

Acquisition of target : In the instruments described above, the target was sought by moving the aerial back and forth. In many cases this is inadequate. Also it is not sufficient to pick up isolated targets. What is needed is an overall picture of the whole situation in a given area, where excessive accuracy in range and bearing values is not required. Surveillance equipment of this kind included the *Jagdschloss* and *Kulmbach (fig. 13)* on the German side and a number of similarly constructed radar stations on the Allied side (cf. *fig. 15*). A large screen — Plan Position Indicator — showed an illuminated picture of the neighbourhood with all air targets, both friendly and hostile. Friendly aircraft were identified by means of automatic identification radio equipment (I.F.F.).

Considerable fame was achieved by the British *H2S airborne panoramic radar*, which was originally designed for submarine detection but was soon also used for air navigation and bomb aiming. This equipment was the first to work on *centimetre waves*, which enabled dimensions and weight to be so far reduced that it could be fitted in aircraft.

Fig. 10 shows the operation of panoramic equipment in diagrammatic form. Rotating aerial *A* is driven by motor *M* ; transmitter *S* — pulse modulated by pulse transmitter *J* — is shut off from receiver *E* during transmission by a pulse from tube *N*. When the pulse is

Fig. 19 : Mobile airport panoramic equipment (and VHF D/F equipment) made by E. K. Cole Ltd., (Britain) for one-man operation, mounted on a standard R.A.F. truck : carrier frequency in X band.

Fig. 20 : Mobile airport panoramic radar, type SP, produced by Société Française Thomson-Houston (France), jacked up ready for operation : aerial rotation speed 12 r.p.m ; carrier frequency 2,900 to 3,100 mc/s ; pulse frequency 1,200 c/s ; range 15 to 60 miles.

Fig. 21 : The American Gilfillan **Quadradar** transportable airport radar for surveillance, landing approach, height finding and taxi control (weight 1,800 lbs.) works with a single remote screen (right), operated by a switch.— Range : 20 miles distance and 50,000 ft. altitude.

emitted the pip on screen R is in the centre ; when a reflected pulse arrives in receiver E, it is at point L. Electrical transmission system U synchronizes the rotation of the magnetic deviation system in the picture tube with the aerial. As the light-sensitive film on the screen continues to glow for a certain time, every reflecting body is correctly indicated on the screen. — The apparatus thus solves the problem of detection in ideal manner. All panoramic equipment for use against ships and aircraft, including the surveillance radar used at civil airports, today have rotating or automatically swinging aerial arrays.

Quality of radar image : Because early panoramic equipment in Germany used metre waves, its aerials were of very large dimensions. After the change-over to centimetre waves, aerial length could be reduced. The first equipment in which this was done was the *Kulmbach (fig. 13)*, whose aerial measured 23 ft. (7 m). The panoramic equipment developed in the United States, Britain and France since the war work on still shorter waves—3 cm and 1.5 cm. Aerial dimensions have therefore been still further reduced, though retaining a high degree of angle resolution. *Fig. 15* shows a modern American fighter control radar, *figs. 14 and 17* airborne radar for all-weather fighter and naval operations. Finally, *figs. 18 to 21* show airport surveillance radar of British, American and French design, which enable the observer to supervise all runways in bad visibility. The wavelength used by the mobile Decca 424 radar equipment *(fig. 18)*, for example, is approx. 3 cm, and max. aerial span roughly 13 ft. (4 m). This gives an angle resolution of 0.75° and a radial resolution of about 50 ft. Thus radar scopes today make even small details identifiable.

The aerial rotating period necessary to produce the picture sequence is several seconds as a rule, e.g., 2.5 or 5 secs. However, it has been possible to match the screen's afterglow to the rotation period so that, despite the slow rotation of the cathode ray, the clear impression of an overall picture persists. When the instrument itself is moving (radar on board ships or aircraft), the afterglow of the previous image is only slightly disturbing. Whereas in older equipment the bright rotating beam was very dazzling to the eye and made it difficult to detect details, it has now been possible to cut out the beam almost entirely, with the aid of the colour difference between direct light and afterglow. This is done by a selective light filter, in front of the tube, which absorbs the direct light. The development of better afterglow films for the cathode ray tube has also greatly contributed to the frequently outstanding brilliance and clarity of today's radar images.

Observation of image : Watching a radar screen for several hours is a straining and tiring task. It would therefore be ideal if the image frequency could be increased to such a level (roughly 20 per second) that the whole screen — like a television screen — has the same background brightness. This will probably be possible only for short-range equipment, however, as the number of pulses (which determines the highest picture frequency) depends on the range. It would seem that a physical limit has been reached here. However, it is not certain that the best compromise between picture frequency, angle resolution and afterglow, from the point of view of operator fatigue, has yet been obtained.

Fig. 22 : Mobile surveillance radar, type R.L.521, of Société Française Radioélectrique (France) with tent : carrier frequency approx. 3,000 mc/s ; built up from 100-lb. units : total weight approx. 1,800 lbs.

Fig. 23 : Radar-controlled tail armament (twin cannon calibre 20 mm) in the Boeing B-47E **Stratojet** six-jet strategic bomber. The automatic fire control equipment for the unmanned tail position is made by General Electric (U.S.A.) and the Crosley Division of AVCO Corporation.

Another weakness is the often inadequate brightness of the radar image. Brightness should in any case be increased sufficiently to enable the screen to be read in daylight. And it may also be asked in many cases whether the permanent employment of human observers is the best method of evaluating radar images. In the case of equipment used for aircraft reporting, weather observation, prevention of collisions, the general picture frequently does not change for days or even weeks. Observers tend to become sleepy, and the incident being watched for can easily be overlooked. Equipment should therefore normally be left unattended....and a warning signal sounded when anything really " happens ".

Three-dimensional presentation : The radar image shows two dimensions only. Panoramic equipment, of course, searches the whole air space but produces only a plane picture. It is thus obvious that any oblique distance shows up as a map distance. Furthermore, no altitude readings are given. In the Precision Approach Radar aircraft approaching to land are shown in plan and elevation. The American Gilfillan GCA *Quadradar (fig. 21)* shows height indications (as well as final approach and airport taxi manœuvres) on the same screen as the surveillance picture, at the turn of a switch. The Teleran system solves the height-finding problem by including in the reflected information code signals emitted by the aircraft to denote its height, upon which the ground equipment sorts out the aircraft according to altitude. For civil air transport, which follows fixed airways, this is sufficient. Nevertheless it remains a task of the future to develop radar images with three-dimensional presentation, possibly in the form of plastic television pictures. — Another problem is to search the air space in sufficiently fine altitude layers. If the time taken for the whole picture is too great, picture sequence and information will be too slow.

Wide-range installations : As the radio waves used in radar have almost optical qualities and therefore cannot follow the earth's curvature, it is impossible to detect low-flying targets over great distances. Topographical features (hills etc.) also as a rule prevent a whole country from being covered by a few long-range stations. It is therefore important, for both air raid warning service and air traffic control, to have overall pictures of the air space picked up by short-range equipment and transmitted to one or more central stations.

For this purpose the essential content of the radar image is compressed on to a narrow frequency band, with a width of from 100 c/s up to 15 kc/s. These pictures can thus be transmitted by normal telecommunications channels. Several different systems to this effect have been developed, in particular in the United States.

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Only a few of the problems of radar technique have been touched upon here. Space prevents any detailed discussion of the radar equipment for the *control of fighters by ground stations and airborne equipment (figs. 11-17)* or of *radar fire control equipment for aircraft armament (fig. 23)*. Similarly no mention has been made of the vast subject of enemy jamming and the requisite counter-measures, the effect of undesired ground echoes and reflection from waves at sea ... or, finally, of a great many other problems which already fill 28 volumes issued by the Massachusetts Institute of Technology. Today thousands of scientists, engineers and technicians throughout the world are working on the problems of air transport control and the air raid warning service. German industry, too, at present barred from working in this fields is confidently looking forward to making a new contribution to the development of radar.

New Look in Weapons Planning — VI:

Fire Control Equipment for Light Anti-Aircraft Artillery

BY LIEUTENANT-GENERAL D. G. H. BRETHOUWER, DIRECTOR,
N. V. HOLLANDSE SIGNAALAPPARATEN, HENGELO, HOLLAND

The increased speed of post-war aircraft has confronted the anti-aircraft gunner with new and difficult problems. Light and medium anti-A.A. guns (up to 3 ins. in calibre) using only simple aiming aids and tracer ammunition have been found to be insufficient against near-sonic aircraft. Moreover, modern aircraft themselves are more robust in construction, so that it generally takes more than one direct hit to bring them down.

To attack high-speed aircraft flying at altitudes up to 13,000 ft., *anti-aircraft guns* must be provided with *fire control equipment*, plus search-lights for night operations. A modern fire control system comprises the following four elements :

Element 1 **detects** enemy aircraft and provides adequate warning.

Element 2 **measures** range, altitude and azimuth of the target in relation to the gun, as well as its direction of flight.

Element 3 **calculates** the target's future position, the point where target and projectile should meet.

Element 4 **transmits** these values to the gun or battery of guns, allowing for ballistic considerations, weather conditions and parallax between the director and the gun.

The introduction of *radar* has greatly improved the accuracy of fire control equipment, in particular for use by *light anti-aircraft artillery* against low-flying targets.

However, "the soul of the artillery is the shell" *("L'âme de l'artillerie est le projectile")*, and it is the shell which determines a battery's tactical use. The smaller the shell, the more difficult it is to provide it with a time or proximity fuse. Hence impact fuses generally have to be used, which means that light anti-aircraft artillery can be effective only when a direct hit is scored. *Precision control is therefore essential.* There are those who consider that the light anti-aircraft gun's high rate of fire is sufficient in itself, but even if a gun fires 240 rounds a minute, which means that the shells reach the target position at ¼-second intervals, the aircraft has time to cover anywhere from 160 to 250 ft. in each of these intervals. Hence the information calculated for the first round is inadequate for the second, and a *continuous* aiming fire control must be used.

Light anti-aircraft artillery belongs to the highly mobile units, and its tactical use involves frequent rapid change of position. Each gun must therefore have its own warning and acquisition radar for fire control. A central radar acquisition system shared by several fire control instruments reduces mobility and creates communications problems.

To ensure adequate mobility in the field, fire control equipment must be of robust design but light enough to be carried on one trailer. It has been found that—for reasons of reliability—mechanical control apparatus is preferable to electronic controls, wherever the former is practicable. In any case fire control equipment must be of simplest possible design, with the minimum number of components.

Though modern fire control equipment must be capable of serving more than one gun, it is not always desirable that it should do so, as stated above. In any case each individual gun should have its own computor. It is often claimed that to supply a separate fire control system for each gun is too costly, but it would be more correct to say that the use of more than one gun with the same fire control system is too costly, since the latter can handle only one target at a time, and each target can be attacked effectively by only one gun.

Fire control equipment must meet numerous specifications (such as K-/114, Interservice Specifications for Telecommunications Equipment), which should, however, be drawn up with due regard to practical requirements.

« New Look » in Weapons Planning — VII

Anti-Aircraft Tanks versus Ground Attack Aircraft

BY COUNT SEHERR-THOSS, GRÄFELFING, MUNICH

While fire power and mobility of ground attack aircraft have been constantly growing, the land forces have by no means kept pace. However fast, mobile and powerful the modern mechanized army may appear, it is nevertheless severely handicapped : its principal offensive weapons on land, 20 to 45-ton tanks, have a maximum speed of 30 m.p.h. and need up to five trucks of supplies each. The high vulnerability of such units to air attack is obvious. " Flying tank-busters "—the name given from 1942 onwards to the American *Thunderbolts* and *Lightnings*, the British *Hurricanes* and *Spitfires*, the Russian *Stormoviks*—became the decisive weapon against the German armoured units in North Africa and France. Once they came in for a low level attack there was little prospect of escape.

The vulnerability of conventional armoured divisions comes from the huge slow-moving tanks themselves and their heavy requirement of supplies, particularly fuel. The generally undefended tank supply columns can be put out of action by even small H.E. bombs, whose blast and splinter effects damage at least the trucks' fuel systems and radiators, while fuel trucks are as a rule immediately burned out. With today's rocket projectiles and napalm bombs, however, direct attacks on tanks themselves are nearly always successful. Their

armour plating is only 20 to 30 mm thick on an average, and rocket projectiles with hollow charge can pierce steel plates 200 to 250 mm thick at any angle of impact. The tank's air intakes for engine and radiator can also frequently be damaged by aircraft cannon.

At any rate, it was no major feat to set German *Tiger* or *Panther* tanks on fire. They had heavily overloaded petrol engines and sadly complicated fuel systems. The heat in the engine room, combined with leaky fuel leads, often caused fire and explosion even without enemy action. Radiators in the *Tiger* were so badly protected from above that they were put out of action by bomb or shell splinters.

However, there is a means of defending armoured units against the threat from the air, namely *anti-aircraft tanks*. On the German side they had been demanded by General Guderian in 1943. In his view a complete efficient armoured unit should include not only tanks, armoured artillery and anti-tank vehicles but also armoured anti-aircraft guns on tracked vehicles. The latter should have the same armour plate, speed and mobility as the other weapons, should move with the unit to protect the latter's " air space " when on the move, in position or in attack. This division of duties is necessary because the tank commander has so much to do with detecting, watching and engaging his enemies on land and with his command duties that he has no time to watch the sky as well ... leaving aside the problem presented by the speed of modern aircraft.

The land units had already been equipped with machine guns for use against aircraft in the thirties (mounted on vehicles, infantry tripods). When the machine gun ceased to be effective, self-propelled guns were introduced, i.e., ordinary ground carriages were screwed to wheeled or half-track vehicles. Chief drawbacks of this arrangements were that driver and engine were insufficiently protected, the field of fire in the direction of travel was limited, and there was too little room for ammunition stocks. Tank commanders never really took these anti-aircraft units seriously and left them behind. In fact they were useful only for protecting columns on the move on road or rail.

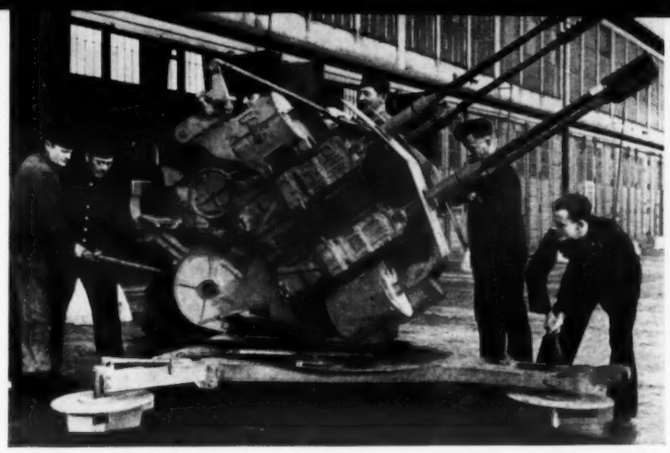
On the other hand the following requirements were laid down from the beginning for the new anti-aircraft tanks :

— two to four automatic guns of adequate calibre ;

— traversing range 360° ; elevating range — 10° to + 80° ; hydraulic laying for high speed ; large ammunition supply ; complete radio equipment ;

— full armour protection for the whole crew against ground and air attack.

The German anti-aircraft tanks built by Krupp and Ostbau-Werke were the first of their kind. Originally they were a combination of existing anti-aircraft guns and the type IV tank of about 20 tons. Whereas, however, Krupp's model (left in picture) was still a pure self-propelled gun carriage, as the side walls had to be lowered during action, the *Wirbelwind* and *Ostwind* types came much closer to the ideal anti-aircraft tank. Their hand laying speed was 28°/sec and was later improved to 60°/sec by means of a hydraulic system. These vehicles were only 8ft. 6ins. (2.6m) tall and could carry more than 2,000 rounds of ammunition. In so-called " mixed operations " the higher rate of fire of the 2-cm weapons (medium range) was combined with the lower rate of fire and longer range of the 3.7-cm guns. This solution, too, was thus only an improvization.



This Rheinmetall 103/38 four-barrelled anti-aircraft gun (on ground mounting) fired 30-mm rounds at a rate of 4 x 420 a minute, with a muzzle velocity of roughly 3,000 ft./sec. It was mounted on a Krupp tracked self-propelling carriage (type IV). (Photo taken in November 1944 ; extreme right the author).

A far better solution was promised by Daimler-Benz's *Kugelblitz*, several prototypes of which were built. Designed by Senior Engineer Kurt Ebel to proposals of tank officer von Glatter-Götz, the completely encolsed turret of this tank consisted of a spherical dome, in which guns, ammunition and operating mechanism were concentrated, traversing and elevating with the guns. The dome rested on a ball bearing nearly 6ft. 6ins. (2 m) in diameter, which was protected by a collar. All movement was hydraulic; guns were 3-cm twin Rheinmetall 103/38, a development of the well-known MK 103 aircraft cannon. This weapon had a sufficiently high muzzle velocity for anti-aircraft purposes (approx. 3,000 ft./sec = 900 m/sec) and the particular advantage of a belt feed system. The stereoscopic sight was fully armour-plated. Target details were passed to the gunner by the commander. Several models of the *Kugelblitz* were captured by the British at the end of the war, but all design documents fell into Russian hands.

In an attack the anti-aircraft tanks operated in the rear of the unit. Their main task was to engage air targets up to an altitude of about 3,300 ft. (1,000 m), though they had to be ready to meet any other emergency. The smallest operationalunit was to consist of four tanks. Each had a crew of four: driver, layer, loader and commander. — Radio communication was provided between tanks, but distance measuring was considered unnecessary (at best the crew had time to decide whether the target was within range or not). Additional requirements for new designs would be better visibility for the commander, suitable means of exit for the crew and good ventilation to permit the excape of powder fumes produced by the high rate of fire in an enclosed turret.

Anti-aircraft tanks in mixed operations : left (without gun) Krupp's self-propelling tracked gun carrier : centre, an Ostbau Wirbelwind anti-aircraft tank with 2-cm Mauser-Rheinmetall type 38 four-barrelled gun (4 x 480 rounds per min ; muzzle velocity approx. 1,970 ft./sec = 600 m/sec) ; right the Ostwind anti-aircraft tank (Ostbau) with 3.7-cm Rheinmetall type 43 single-barrelled gun (250 r.p.m ; muzzle velocity 2,460 ft./sec = 750 m/sec).

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Future requirements. In view of the progress made in weapons development in the atomic age, in particular the tactical A-bomb for ground attack aircraft, a reversion from the traditional heavy armoured units to fast-moving light groups adequately protected from air attack is more than ever necessary. These units must be composed of small vehicles of very high fire power and capable of carrying their own supplies. They must be able to concentrate or disperse rapidly, be easy to camouflage and leave few traces behind on the ground. An air raid on such small " quick-silver " targets would be scarcely worth while and could frequently be escaped through the unit's high mobility. Increasing manœuvrability and mobility of the land forces, in conjunction with good anti-aircraft protection, may even so greatly augment the difficulties of ground attack aircraft that the days of the " flying tank-buster " may be numbered.

"New Look" in Weapons Planning — VIII

New Anti-Aircraft Guns and Fire Control Equipment

Above : Travelling and firing positions of the L/70 automatic field and anti-aircraft gun (calibre 40 mm) of **A.B. Bofors** (Bofors, Sweden), on single mounting with hydraulic control.

Below : Travelling and firing position of the electrically remote-controlled twin-barrelled anti-aircraft gun (calibre 34 mm) of **Hispano Suiza** (Geneva). The electric motors for elevating and traversing are clearly discernible.

61La/5TG light anti-aircraft gun (calibre 20 mm) of **Oerlikon Machine Tools Ltd., Bührle & Co.** (Zurich) in firing position : elliptical sight, hand control, rate of fire 1,000 r.p.m., muzzle velocity 3,700 ft./sec (1,120 m/sec).

Despite all progress in the development of anti-aircraft rockets, there is still need for light and medium anti-aircraft guns to combat low-flying aircraft. These must, of course, as General Brethouwer points out in an earlier article, be equipped with efficient fire control apparatus and automatic laying equipment (hydraulic or electric servo motors) of high speed and stability. Only ultra-light anti-aircraft weapons, such as the Oerlikon 6ILa/5TG 20-mm pictured here are still fitted with pure manual control and simple sights or are provided, like the Hispano Suiza 30-mm gun, above right (type 831 on 641 mounting), with supplementary powered laying drive (2½ h.p. four-stroke petrol engine ; mechanical gear ; tow control levers for traversing and elevating).

First pictures and details have now been released of two new medium-heavy anti-aircraft guns of latest design, both of them with fully automatic control, the Swedish *Bofors L/70 40-mm gun* (with hydraulic power operation) and the Swiss *34-mm Hispano Suiza* twin-barreled gun (with electronic-electrical control.) — Both can be towed at high speeds and be made ready for firing within a few minutes : the crew removes the wheels, steadies the carriage on the ground by means of screw-operated levelling jacks and connects up the cables to the *fire control equipment* and the *power supply*. In Switzerland (and a number of N.A.T.O. countries), predictors and computers developed by *Contraves A.G.* (Zurich and Rome) are used. Similar equipment is also produced by *A. B. Bofors* (Sweden), and *Société Française Radioélectrique* (Paris), and *N. V. Hollandse Signaalapparaten* (Holland). For the electrical control of the Hispano Suiza gun, the Swiss Military Department, in conjunction with *Standard Telephon und Radio A G.* (Zurich), has developed mobile power stations mounted on cross-country trucks.

Technical details for the Bofors L/70 automatic anti-aircraft gun on field carriage : calibre 40 mm, barrel length 70 calibres, rate of fire 240 r.p.m., muzzle velocity 3,280 ft./sec. (1,000 m/sec), elevating speed 45°/sec, traversing speed 85°/sec., elevating acceleration 135° sec.², traversing acceleration 127° sec.², weight of gun without ammunition 10,100 lbs. (4,600 kg), weight of exchangeable barrel assembly 385 lbs. (175 kg.) recoil force 5,950 lbs. (2,700 kg), wheel base 157.48 ins. (4,000 mm), wheel track 66.93 ins. (1,700 mm), ground clearance 15.4 ins. (390 mm).

The gun, a precision weapon of high fire power and outstanding laying qualities, fills the gap between heavy anti-aircraft guns and light machine guns. It is particularly suitable for use against low-flying aircraft. The high rate of fire is obtained by an automatic loading system, the rounds being rammed during the run-out and the spent cartridge cases ejected towards the end of the recoil. The gun platform carries two ammunition racks, each holding six chargers, which in turn contain four cartridges. Two gunners (on the platform) fill the automatic loader with these chargers, one from either side. They are protected from the high traverse acceleration of the mounting in power control by waist-high supports. The racks must be kept filled from the outside (by the ammunition supply party) if full advantage is to be taken of the high rate of fire.

The gun is elevated and traversed *hydraulically and automatically*, in response to pulses from the fire control equipment. If the latter fails, local control is provided by means of a one-man joystick used in conjunction with a close-range sight. If the power supply to the hydraulic servo controls breaks down the gun can be elevated and traversed entirely *mechanically* (by means of two hand wheels). The *firing gear* consists of a solenoid which is electrically operated by the remote fire control equipment or by a pedal from the joystick operator's position. The gun's front shield is 5mm thick, so protects only against splinters.

The *shells* fired by the Bofors gun are 40-mm H. E. shells weighing 2.12 lbs. (0.98 kg). Each complete round weighs 5.3 lbs. (2.4 kg), each charger 22.5 lbs. (10.2 kg). Time of flight to 6,500 ft. (2,000 m) 2.4 secs. Burning time of tracer 4.5 secs., time to self-destruction 8 secs., and corresponding range 5,017 yards (4,670 m). Maximum horizontal range is 13,800 yards (12,600 m).

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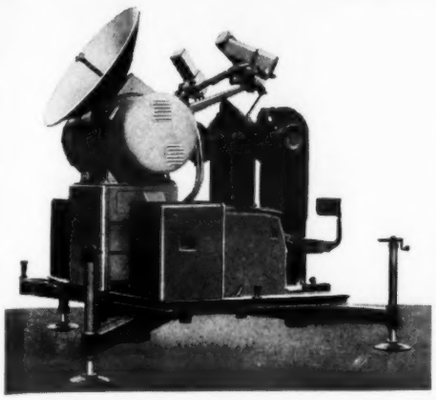
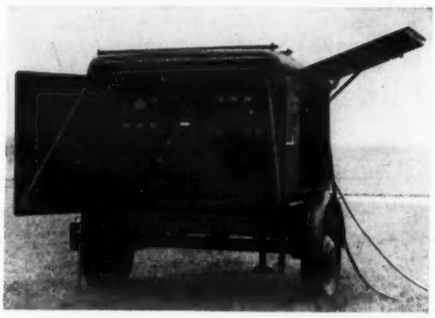
Technical details for the Hispano Suiza automatic twin-barreled anti-aircraft gun : calibre 34 mm (or 40 mm) ; barrel length 74 calibres ; rate of fire 2×450 to 2×500 r.p.m. ; muzzle velocity 3,280 ft./sec. (1,000



Contraves (Zurich) predictor for 3-inch and 40-mm guns, with optical range-finder and fire control radar. The predictor passes measured data (bearing, altitude and range of target) to the computer.



Electric computer for elevation and bearing of gun barrel and for setting the fuse time, designed by **Contraves** (Zurich), mounted on a trailer. The computer and the predictor pictured alongside together make up the fire control equipment.

Light anti-aircraft gun 831/641 (calibre 30 mm), made by **Hispano Suiza** (Geneva), with mechanical laying by petrol motor, in firing position : elliptical sight ; rate of fire 600 to 650 r.p.m. ; muzzle velocity 3,020 to 3,210 ft./sec (920 to 980 m/sec) ; barrel length 70 calibres ; drum feed (20 or 40 rounds), belt feed (50 rounds) or continuous feed by means of chargers containing 5 rounds.

m/sec) ; elevating speed 50°/sec ; traversing speed 100°/sec ; weight in travelling position 7,930 to 8,380 lbs. (3,600 to 3,800 kg) ; four-wheel or two-wheel carriage ; magazine for 2×50 rounds.

Unlike the Bofors gun, which uses hydraulic servo controls, *Hispano Suiza's* 34-mm twin gun has entirely electrical laying control. Two electric motors provide elevating and traversing movements in response to pulses emitted by the fire control equipment and transmitted without delay via electronic amplifiers. Here too, however, loaders and ammunition supply crew are needed to feed the automatic loading system of the twin-barreled gun, so as to ensure effective continuous fire at full speed. If required, the same gun can be supplied with 40-mm barrels, with the same rate of fire and muzzle velocity.

New Look — IX

Packaged Bombers

Martin B-61 Matador tactical pilotless bombers, made by The Glenn L. Martin Company, Baltimore, Maryland, have been stationed in Europe since this spring. A short time ago the U.S. Air Force demonstrated them to the press at Bitburg, Eifel. These robot bombers take off, using their own Allison turbojets plus powerful take-off rockets, from a short cross-country launcher. They are slightly bigger and much faster than the German V-1. In wartime they could be equipped with atomic warheads. They are guided either from the ground (using radar and remote control desk) or from accompanying aircraft.

Pictures show how the supply problem for this new-type weapon has been solved. The manufacturers deliver the bombers in packaged form, with a mere seven harmless-looking crates containing all parts for the robot in weather-proof packing. The parts can be stored indefinitely and are interchangeable. Assembly takes only a few hours, and fuel, rockets, warheads are brought up by special vehicles.

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Track Undercarriages for Aircraft

BY GENERAL HEINZ GUDERIAN

The vulnerability of large air bases of conventional type was illustrated by means of examples in the previous issue (N.A.T.O. special issue No. 1, July), and a number of suggestions made for overcoming this disadvantage in regard to fighter units. — What is the position of the transport aircraft, no less essential in modern warfare ? Stalingrad had already shown that it is impossible to operate a large-scale air supply system when the enemy renders its air bases unserviceable, and the jungle fortress of Dien Bien-Phu furnished another example this spring.

*In an article which appeared two years ago in " Wehrwissenschaftliche Rundschau ", the late General Heinz Guderian, leading German World War II tank specialist, advocates the use of cross-country caterpillar tracks for front-line transport aircraft.**

Editors

It is often said that every new war begins where the last left off. This view is false, for the time of peace between two wars is not a sterile period as regards military development, and anyone who—feeling himself well abreast of progress—allows himself to slumber after a war may suffer a rude awakening when the next conflict opens. The loser is less subject to this danger than the winner, who comes home crowned with laurels and as often as not convinced of his superiority. This is what happened to the Prussians before their encounter with Napoleon, which led Queen Luise to state after the defeat at Jena : " We had rested on the laurels of Frederick the Great. " This is what happened to the French after World War I, when they—exhausted by their losses—subordinated tactics and strategy to the existence of the Maginot Line rather than to the demands of the political and strategic situation. The Germans were astounded by their French opponents in 1940 ; not only tactics and strategy, but also arms and equipment seemed to date from 1916, while the fighting spirit of those earlier glorious days had vanished. The outcome of the 1940 campaign in France showed that the tactical and strategic progress made by the vanquished since 1918, progress which had naturally also affected arms and organization, gave him a surprise victory, which came so fast that his adversaries spoke of lightning war.

We must therefore never rely on the next war beginning where the last left off. What we must do is try to penetrate the mist of uncertainty that veils the future, and endeavour, despite the limited view and varying information, to exploit and improve today's technical possibilities and advances, and put them to the service of new political, economic and military ideas.

We are today experiencing an intensive effort towards progress in many fields, such as atomic research, guided missiles and rockets and other domains which serve both peaceful progress and military purposes.

It is everywhere admitted that one of the most important technical possibilities of today and the immediately foreseeable future lies in the development of motorization on the ground and in the air, that the aircraft will be required to perform more and more new tasks as civil and military transport and as combat weapon.

A glance at the part played by the aircraft as transport and combat weapon in World War II will show what will doubtless be needed in future. It will throw light on where the main weight of development has been laid and where it should be laid in future, to meet all foreseeable eventualities.

1942-43 : Supplies totalling 500 tonnes a day were to have been flown into Stalingrad, but because of inadequate landing grounds, which soon became strewn with craters and wreckage, the Luftwaffe managed only a total of 6,591 tonnes in 70 days, a daily average of 94 tonnes. Best day's figure was 295 tonnes.

Historical examples from World War II

On the German side in World War II aircraft were used not only for pure combat purposes but also to transport men and material, to supply isolated units, to remove the wounded. Here it is sufficient to mention Narvik (1940), Eben-Emael (1940) and Crete (May 1941). These operations succeeded because air mastery was held entirely, or almost so, by the Germans and because distances were short, and aircraft could return to their bases on one fuel load. In the case of *Crete* distances for the Germans were 75 to 100 miles, but for the British 300 to 600 miles. Yet the landing on Crete had to be made : " On the evening of the first day the situation was anything but promising. Until we had an airfield in our hands, the 5th Mountain Division, which was to be landed by transport aircraft, could not be sent in. " [1] The dependence of airborne troops on the availability of a serviceable airfield became clearly obvious. Only when Maleme airfield fell into German hands could sufficient forces be brought up on the second day, and British resistance broken. Up to that time German losses had been heavy.

* Reproduced by permission of the publishers of « Wehrwissenschaftliche Rundschau », Vol. II, No. 5 (May 1952). Publishers E.S. Mittler u. Sohn G.m.b.H., Darmstadt.

[1] von Tippelskirch, *History of World War II.*

The situation at Stalingrad in the winter of 1942-43 was a very different one.

At Stalingrad the German 6th Army numbering not quite 300,000 men was surrounded by the Russians on November 19th, 1942. By November 21st the suggestion of carrying in supplies by air had already been made.

Very soon supply difficulties within the encircled area became so critical that all thought of breaking out had to be abandoned because of lack of mobility (i.e. of fuel), while at the same time Hitler's fanatical determination to hold on to what had once been conquered rejected any idea of breaking out, promising relief.

Essential conditions for adequate airborne supplies would have been :

a sufficient number of transport aircraft,
a safe ground organization outside the enclosure perimeter,
and good airfields inside the cauldron of Stalingrad[2].

Such was the view of the responsible German Air Force chiefs at that time, and it must be pronounced a good one for those days. However, none of these conditions were met.

The plan was that 300 aircraft should fly 200 to 600 tons of supplies of all kinds into the cauldron every day, a quantity which was not in itself overwhelming and which even appears quite small compared with the performance of the United States Air Forces in the later stages of the war. But it was the utmost the Luftwaffe, summoning up all its forces, could then do. To achieve even this, it accepted heavy losses, for—like the Army—it was well aware of what was at stake. And yet there was only one day on which the quantity of supplies flown in reached 295 tons. The average daily load was 94.16 tons, and the total load 6,591 tons.

If we seek the reasons why the plan to supply Stalingrad from the air broke down, we come to the lack of airfields. Without hard runways our machines could neither take off nor land. Even the take-off bases were not good and suffered through the winter weather, while the landing grounds in Stalingrad were in very bad condition. They were exposed to superior enemy air action and very soon to Russian artillery too, and their runways were soon covered with craters made by bombs and shells of all kinds, with the wreckage of damaged aircraft, with discarded containers—and with dead. Landing and take-off on these desolate fields became more and more hazardous as the weather deteriorated. Snowdrifts covered in the craters and unevenesses of the ground, losses grew, the quantities of supplies arriving diminished. And all this happened despite the fact that the ground was flat and without obstructions.

We find that take-off and landing difficulties for our aircraft at inadequate airfields were so great that all the courage and skill of their crews were unable to overcome them. Göring's promise of 500 tons of supplies a day was no more kept than Hitler's promise of relief. And the whole sorry picture was in no wise altered by the belated utilization of high-capacity aircraft.

The Luftwaffe had succeeded in supplying some 3,000 men in the Kholm cauldron and 100,000 men in the Domiansk cauldron, but it was doomed to break down on the problem of supplying an army of nearly 300,000 at Stalingrad.

The war diary of Milch's Staff contains the note : " Many cases of damage to undercarriage and tail wheels."[3] A result of the bad airfields.

There will be those who will say : That was because you Germans had inadequate equipment. We Western victors can do better than that. Did we not supply Patton's armoured units with 1,000 to 2,000 tons a day during their advance on Paris ? Did we not, contrary to your expectations, run the airlift to Berlin and keep a city of millions alive ? Did we not fly in supplies for the Korean War over distances of 5,000 or even 7,000 miles ?

All this is true and yet needs qualification. For these large-scale air operations the Americans had very good take-off and landing bases. They did not undertake such operations unless the essential conditions for their success—suitable airfields—were present, and proper arrangements had been made to supply the air units themselves. This was essential then and is still essential today, as long as aircraft need hard, level runways for take-off and landing.

This brings us to the heart of our problem : Will hard runways always be available for our aircraft, with their increasing size, weight and speed ?

Or must the nations that plan to use such machines to a growing extent not begin to think what will happen if such airfields are not available or if they are rendered unserviceable by enemy action ?

It is not necessary to think of such unfortunate situations as Stalingrad. On the contrary !

The question gains in importance with the speed at which land operations, with which the air operations must be coordinated, can take place, thanks to progress in the supply of cross-country vehicles with caterpillar tracks. Air operations cannot always be organized freely by the Air Force chiefs, but are often dictated by the need for cooperation with Army or Navy.

What happens if, because of the speed and scope of land operations, and in order to make use of the surprise factor, the flying units must be used early, before preparations can be made for runways ? Either situations such as Stalingrad arise, or particularly good tactical and strategic opportunities are lost because the air force is grounded by lack of airfields or its operation demands too high a sacrifice of equipment and probably of men.

Heavy bombers may perhaps be unaffected, because of their long range, but ground attack aircraft, reconnaissance aircraft and above all transports must stay close to the land forces and generally be capable of landing and taking off again in their combat area.

During the brief period from November 24th, 1942, to January 31st, 1943, the Luftwaffe before Stalingrad sustained a total loss of 488 aircraft—214 of which crashed during landing or take-off—and of 1,000 crew members, a heavy sacrifice for a force with limited resources.[4]

[2] Herhudt von Rhoden, *Die Luftwaffe ringt um Stalingrad* (The Air Force Fights for Stalingrad).

[3] Herhudt von Rhoden, *Stalingrad.*

[4] Herhudt von Rhoden, *Stalingrad.*

1948-49 : American and British aircraft flew an average of 5,500 short tons of supplies into the Berlin " pocket " every 24 hours, operating day and night. Top day's figure was 12,849 tons. This was possible, however, only because they had undisturbed use of three first-class airports in Berlin : Gatow, Tegel, Tempelhof (picture).

Requirements of the future

The question of the profitable use of air forces over wide areas and in theatres of operations without prepared airfields thus boils down to equipping such air forces with aircraft that can take off and land not only on prepared runways but also on makeshift strips or even in the open country, provided conditions are not too unfavourable.

Up to the present aircraft have mostly had undercarriages with wheels and pneumatic tyres. Only for alighting on water have floats been used, and occasionally, for landing on snow and ice, skis. On the whole, however, the conventional wheeled undercarriage is the only kind in general use. It was originally taken over from the automobile industry and had remained of the most obvious and simple design. It had the lowest possible resistance during take-off and landing and was relatively easy to retract into the aircraft without taking up too much room. It is still ideal for smooth flat runways, and nothing better appears to be necessary. But would this always be so in wartime ?

Can situations such as at Stalingrad be repeated ?

May not even successful operations break down on technical weaknesses, as for example aircraft that need complicated air bases ?

Must not cooperation between air forces and motorized land forces become closer and closer ?

In Korea the hilly country and the necessity of supporting land forces obliged the Americans to use not only their fastest jet fighters but also to fall back on the old, slower *Mustangs*. And now the helicopter is being used to transport the wounded and to rescue units cut off by the enemy. It can land in the smallest space or—thanks to its low landing speed—in unprepared fields. It follows that supersonic aircraft are not always ideal. But present-day helicopters are too slow and therefore too exposed to danger when enemy counter action must be reckoned with.

Some of the rollers tested by Count Bonmartini for his track undercarriage.

Efforts have therefore been made in several countries for a number of years to add new types of undercarriages to those already mentioned, namely either multi-wheel undercarriages or caterpillar track units similar to those used in tanks.

Multi-wheel undercarriages of various kinds are used for example for American heavy bombers. At present the United States prefers the multi-wheel undercarriage to the track landing gear, but it is the latter that should interest us more, since multi-wheel under-carriages need very tough elastic runways, while track landing gears are designed to make air-craft independent of these. Ground pressure of the B-36 is 170 p.s.i. (12 kg/cm²), of the B-45 as much as 185 p.s.i. (13 kg/cm²), the Fairchild C-119 70 p.s.i. (5 kg/cm²) and the North American F-86 about 140 p.s.i. (10 kg/cm²).

To return to the caterpillar track. The first traces of work on this type of under-carriage lead back to 1926, and *Count Bonmartini* has been studying this important problem in Italy since 1928. Considerable money and effort was spent in the United States and Britain during World War II, but all attempts have so far failed, as it has not yet been found possible to overcome the high friction during take-off and landing which set the tracks, presumably covered with rubber, on fire.

The first successful model of an aircraft with track undercarriage was exhibited by Count Bonmartini at the 1951 Paris Air Show.

Count Bonmartini's undercarriage features an endless rubber tube over four rollers. The rubber tube, reinforced by wire cables, has a narrow, almost sharp section, with small contact surface with the ground. Its specific ground pressure must therefore still be fairly high and reduce cross-country qualities excessively. The system is a combination of pneumatic tyre and caterpillar track. An aircraft with this under-carriage would immediately sink deep into the morass on muddy or snowy ground. Friction will be relatively high, despite the chains. The actual undercarriage shown will thus presumably be applicable only to light aircraft, such as the 65 h.p. Piper *Cub*, and wider tracks be needed for the more difficult conditions named.

Heavier aircraft would need still wider tracks, which would mean increased weight and greater friction.

The tracks on the Piper *Cub* are very short in relation to the fuselage. To overcome broad obstacles they would have to be lengthened. This, however, would again increase weight and friction.

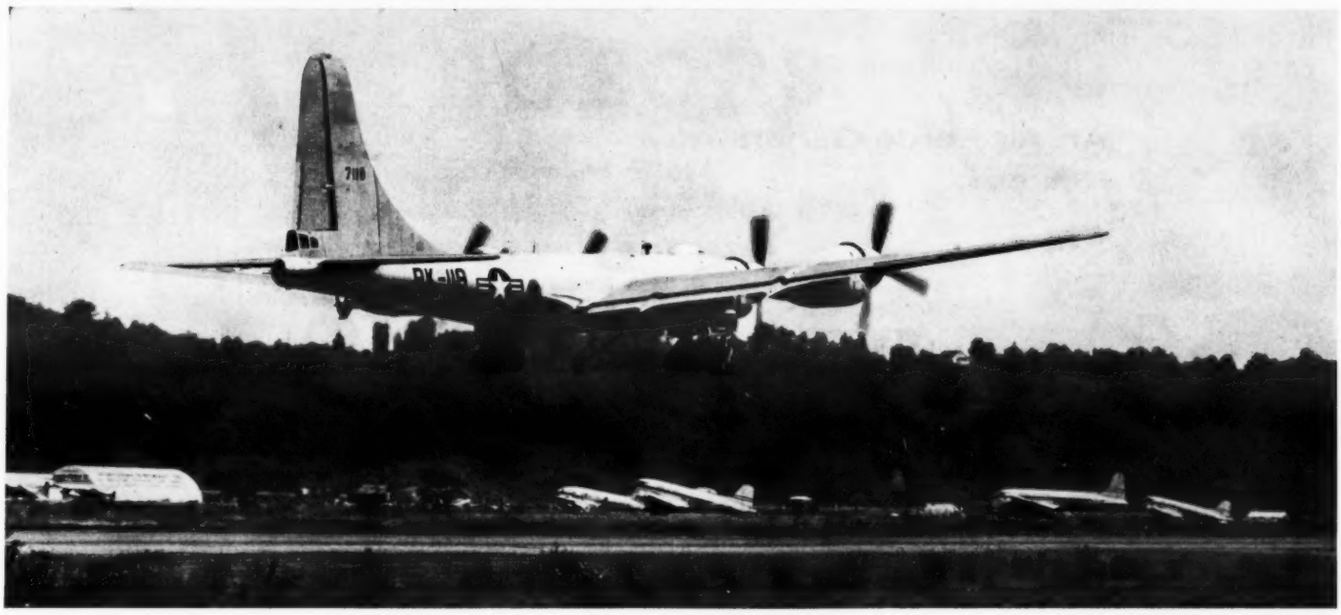
Whether rubber tiring is really necessary for the track, or whether a light metal track of steel or duralumin would not suffice should be closely examined. Shock absorption for the aircraft during landing can be provided in some other way than by pneumatic tyres, e.g., by springs or shock absorbers or a com-bination of both. Moreover the tyres under-neath the rollers during landing may prove to be a source of failure in heavy aircraft.

As regards the suspension of track under-carriages, the only suggestion the layman can make is that they be fitted as close as possible to the fuselage, to avoid nosing over on landing. Another question that could be investigated is whether a very wide track beneath the centre of the fuselage would suffice or whether two tracks are essential. A broad track would so to speak form the belly of the aircraft, and all landings would be literally belly landings. Support rollers at the wing tips would prevent lateral tilting during take-off and landing.

The use of a track system makes the problem of retracting the undercarriage into the fuselage more difficult than hitherto. The track needs much more room than normal wheels. This means reduced payload capa-city. The extra weight of the track undercarriage compared with the wheeled variety already entails a reduction in payload or fuel capacity ; however, this should not be the only factor considered.

But these critical remarks are not decisive. Their object is merely to point out certain transitional phenomena which strike the layman when he first occupies himself with Count Bonmartini's revolutionary idea.

Auster 5 sports aircraft with Bonmartini track undercarriage.



Free the aircraft from its dependence on hard runways: Even four-engined bombers, such as this Boeing B-50, can be fitted with caterpillar track undercarriages.

Decisive figures are given, however, in the following table taken from the April 1951 issue of " Civil Engineering ". It shows the differences between aircraft with track undercarriages and with normal wheel undercarriages :

Aircraft	Weight (lbs.)	Ground pressure (p.s.i.), Track	Wheels
C-82	54,000	25	85
B-50	170,000	50	156
B-36	358,000	57	170

The figures given for ground pressure are approximate.

The advantage of track undercarriages is immediately obvious.

If we consider the increasing length of runways for jet aircraft, the difficulties involved in their surface treatment, their enormous cost, we come back time and again to the track undercarriage, which when suitably designed would overcome many of these difficulties and costs.

Conclusion

To sum up, the following are the salient points on caterpillar track undercarriages :

1. Two-wheel and multi-wheel undercarriages hitherto used in military aircraft need hard runways and taxiways. The faster and heavier aircraft become, the harder and longer landing grounds have to be. They cost much time and money to build. Suitable ground for their construction must be in friendly hands. Communications for bringing up construction personnel, building materials and ground personnel for the air force must already be in existence and operating without threat.

2. If the above-mentioned conditions for the construction of airfields cannot be met, it will be necessary either to abandon any projects for the air force to take part in the operation in progress or, if this is not possible, to produce aircraft which do not need hard runways.

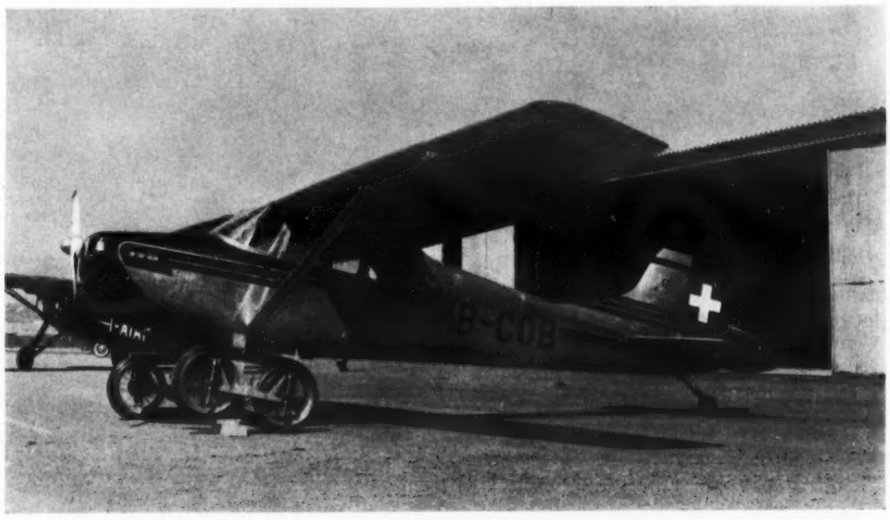
3. Among the designs so far made public only that of Count Bonmartini appears feasible. Although it is at present suitable only for light aircraft, it is to be expected that it can later be applied to heavier models.

4. In the further development of the Bonmartini system attention should be given to ensuring reliable operation of the tracks on soft ground and in snow, so that the undercarriage can also be used safely in unfavourable terrain. It should also be examined how far sources of breakdown, such as the rubber tyres, can be eliminated.

5. If it is possible to apply the Bonmartini design to heavy military aircraft, new prospects will be opened up for their use in conjunction with motorized and armoured units. The air force would then be able not only to support but also to supply rapid operations by tank units independently of hitherto normal means of transport. Operational airfields could be moved up close to the land forces in action. Inter-service cooperation would become closer than hitherto.

6. Such a development would be highly welcome to the tank commander. This is the point of view from which the above article has been written.

Cessna 170 four-seat touring aircraft with latest-model Bonmartini track undercarriage.



PROFILE OF THE MONTH

An Air Force General Retires...

General Bengt G. Nordenskiöld, Commander-in-Chief of the Royal Swedish Air Force, Sweden's first " five-star " Air Force General, retired on June 30th, 1954, on reaching the age limit for his grade.

If his success as Commander-in-Chief was striking, the manner in which he took leave of his squadron was no less so. Under General Nordenskiöld, Sweden became one of the world's six leading air powers, and the Swedish aircraft industry developed to a point where it need not fear comparison with that of many a Great Power. When he took over command of the Royal Swedish Air Force in 1942, it consisted of roughly 400 aircraft, most of them obsolescent. Today it has at least 1,200 first-line aircraft, most of them modern jet-powered types. During his reign aircraft and engine firms—not to mention accessories works—grew up which are really producing in quantity, and even exporting.

The special feature of his farewell ? — The 63-year old General made a round trip of nearly 1,400 miles in one day, at the controls of a J 28B (Swedish licence version of the de Havilland Vampire), making 18 landings and delivering 30 addresses to the officers and men under his command — some of them by R/T. Actual flying time 4 hours 45 minutes... Nordenskiöld may have reached the age limit, but is obviously still a young man.

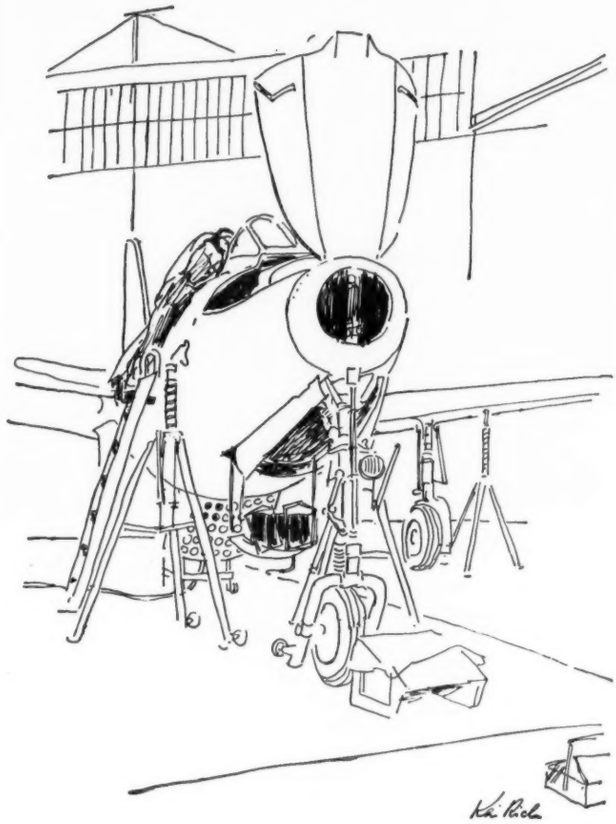
The programme he leaves behind culminates in the effort to get the new Saab 32 Lansen jet fighter into service as soon as possible, and to accelerate production of an even newer Swedish combat aircraft (J 35 ?— 1,000 m.p.h. ?) Finally he advocated energetic measures to produce atomic weapons and guided missiles.

Not that Nordenskiöld is a hot-blooded war-monger. His duty was to provide defensive weapons for Sweden's neutrality... and he leaves his successor a proud inheritance.

...and Another Takes Over

On July 1st, 1954, Lieutenant General Axel Ljungdahl took over Supreme Command. He is 56, joined the Swedish Army in 1921, commanded both bomber and fighter units in succession, and finally became Chief of the Air Staff. His reputation as an air strategist is international. In 1953 he was awarded the Swedish War Academy's Gold Medal.

General Ljungdahl is taking his introductory visits in more leisurely fashion than his predecessor did his farewells. He is to visit one squadron a day and systematically acquaint himself with the complex task he is taking over at a critical period.



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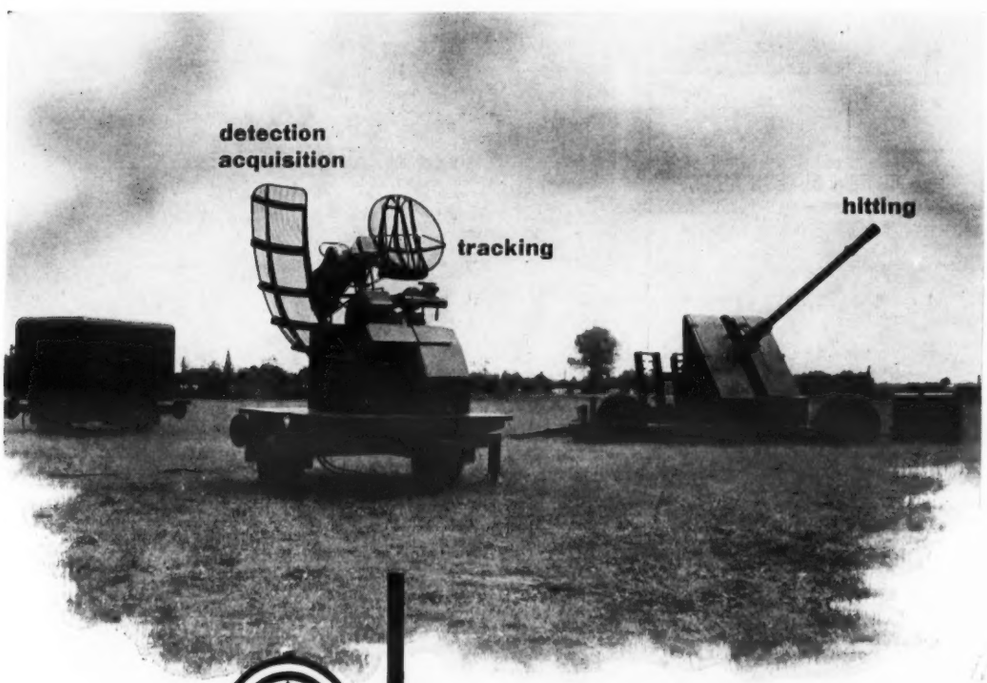

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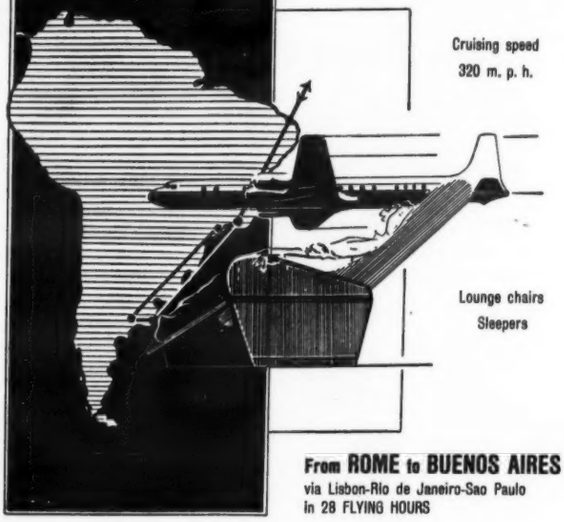

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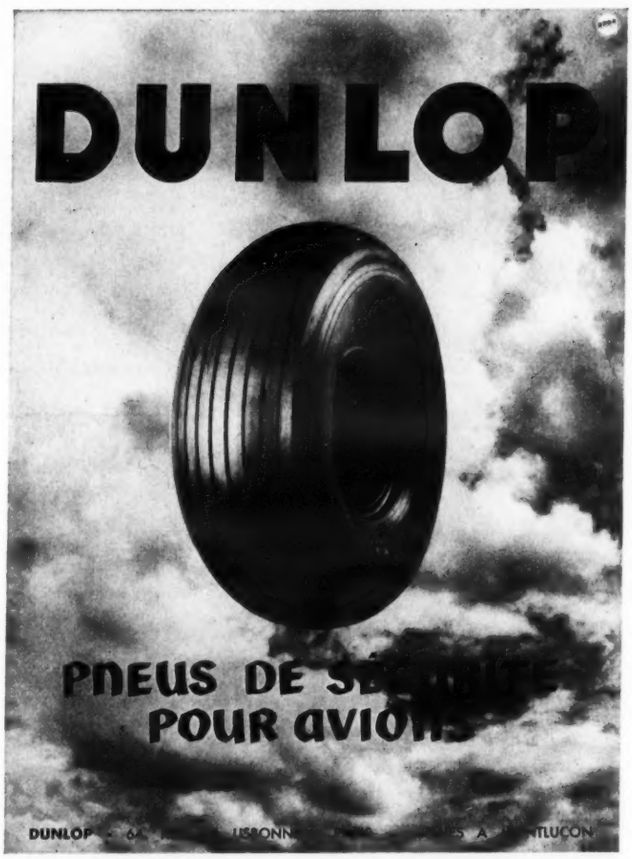

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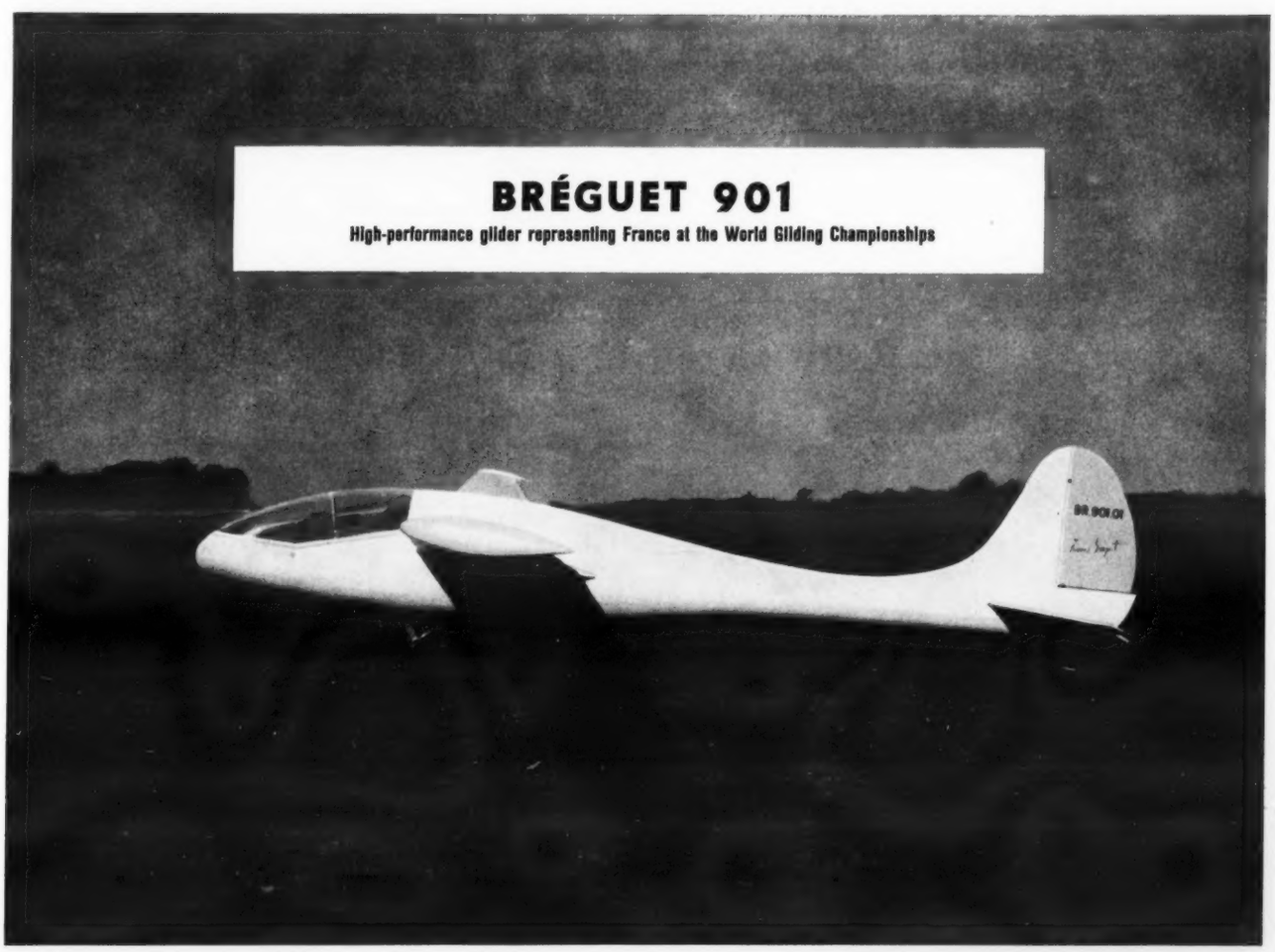

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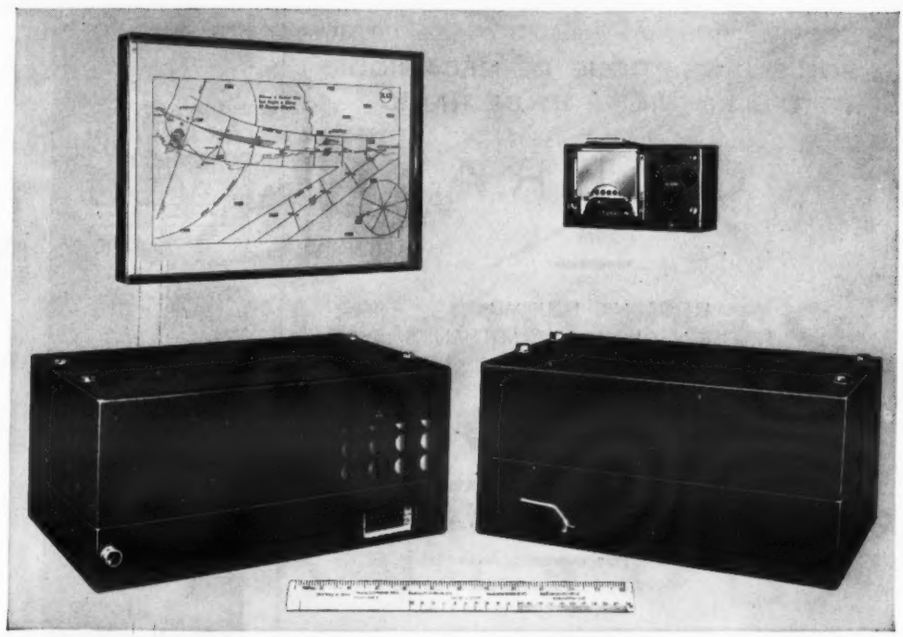

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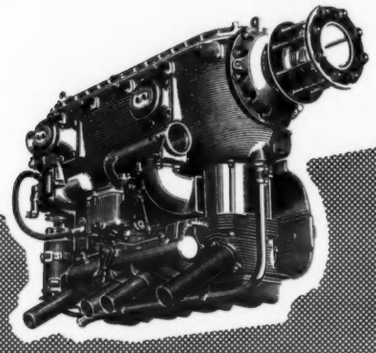

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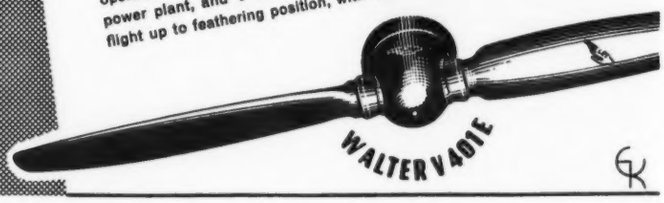

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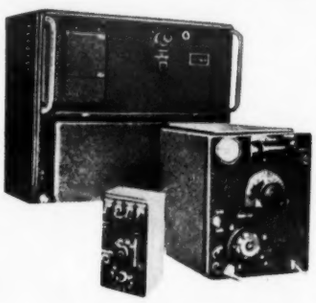

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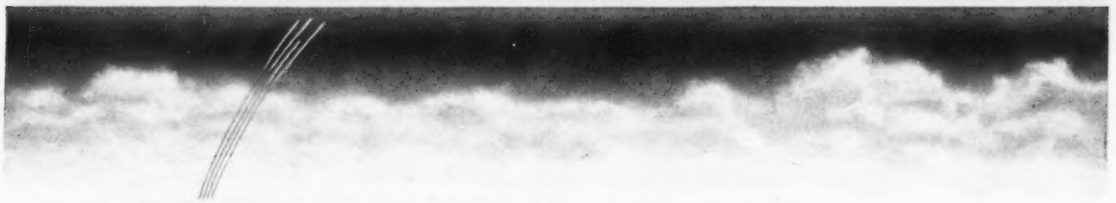

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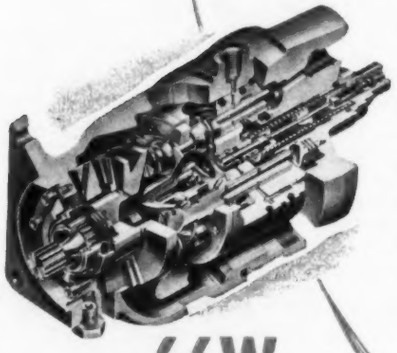

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